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CURRENT TOPICS.

THE ELECTRICAL EXHIBITION AT MANCHESTER.

THE electrical industry in this country has for some years past suffered from a number of ills; chief of these has been gradually falling profits to the manufacturer, and these profits seem so badly distributed that some of the younger firms persist in making a profit, while those interested in the older concerns allege that prices have long ago fallen below a remunerative level.

There has been no lack of physicians who prescribe all manner of remedies, from Protection to exhibitions; and as they cannot just yet have the former, the latter has been tried once more as a business "booster." Three years ago a similar effort to precipitate the electrical millennium was made in London, at Olympia, and now an attack has been made on the hard-headed men of the North-west, in the hope that they will be more susceptible to the advantages and economies of electricity than the Londoner proved to be. In the three years which have elapsed between the two shows, many things have happened, especially in the development of the flame arc lamp and the application of electric power to textile machinery. The former made a most dazzling display at many stands, while the electrically driven spinning and weaving machines made a less ostentatious, but no less interesting, feature on several stands.

The number of actual novelties are, naturally enough, small, though Messrs. Brown, Boveri & Co. seem quite justified in claiming originality and many other merits for their single-phase motors for ring spinning.

The object is to vary the speed of the motor so that the tension of the yarn as it leaves the nip of the rollers is maintained constant.

It is claimed that three important objects are attained by this speed variation: (1) by keeping the tension on the thread at this point always constant, the spinning is better and more uniform; (2) by maintaining a steady tension below that of the maximum attained when running at constant speed, fewer ends are broken; (3) by increasing the speed when spinning on the full diameter of the cop (which is necessary to keep the tension constant) the average speed

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is considerably increased, and an increase of about 15 per cent. is obtained from the frame.

The specially interesting feature is the fact that such speed regulation is obtained entirely without the use of resistances, by utilising the well-known property of the single-phase repulsion motor, whose speed can be varied by merely varying the position of the brushes.

The movement of the brushes is performed automatically either by a mechanism attached to the "heart" shaft, or by a small slow-speed motor, automatically controlled, either of which slowly moves the brushes round the commutator as the bobbin fills up. The system may be applied to all types of spinning frames, the automatic gear being designed to vary the speed according to the requirements of the particular frame, yarn, shape of cop, and number of counts.

About 1,000 such motors are now in operation, 800 on ring spinning and doubling machines. The single-phase motors can be used on one leg of a three-phase system.

The industries of Lancashire and Yorkshire are so diverse, and the efforts made by exhibitors to cater for these requirements so numerous, that an inspection of the exhibits formed the only practical means of becoming familiar with the applications of electricity to these industries. There was, however, a marked absence of novelties, due perhaps to the fact that the last show of its kind was held only three years ago, and also to the efforts of all sections of the technical Press, which give almost immediate publicity to fresh developments in any branch of applied science.

It is to be noted that the Diesel engine for driving generators was well represented, and there seems no doubt that for moderate sized installations this type of crude oil engine is a reliable and satisfactory prime mover.

THE NEW DAIMLER MOTOR.

Widespread interest in motoring circles has been aroused during the past month by the announcement of the Daimler Company of its motor innovation for 1909. For the first time since the noted engineer, from whom this company derives its title, gave to the world the present type of high speed engine which has made the success of the motor car possible, has there been a noteworthy change from the original design. In fact, the original Daimler motor, modified at most in respect of details, has been regarded by the motor world as almost the last word in petrol motor construction. The original poppet valve and seating springs have almost come to be accepted as a necessary part of the design, and efforts to eradicate them from the high-speed four-stroke model has hitherto met with little success.

Hence it may readily be imagined that the definite announcement that the Daimler Company has discarded poppet valves and springs after two years of investigation and tests, and have decided to stake their reputation upon a motor which is an innovation, has been received with interest.

The motor in question is of American origin, and is stated to be smooth and noiseless in the car, economical in operation, and so designed as to considerably reduce the element of mechanical trouble. Poppet valves are supplanted by cast iron tubes or sleeves used as a lining of the cylinder, containing ports which register with one another at desired intervals, being actuated by eccentrics coupled up with

miniature connecting rods. The result is a combination which we see little reason should not give good results, any criticism we have to offer being directed against the facilities provided for taking up wear.

THE SUCCESS OF THE WRIGHT AËROPLANE.

The results yielded by the long-continued trials of the Wright aëroplane at Le Mans in France are such as to indicate that the heavier-than-air type of flying machine bids fair to become established, at no distant date, on a practical basis. The purchase of the invention rights by a French syndicate for a sum of £20,000, following upon performances made under very exacting conditions, will be certain to give an impetus to this method of air navigation, although it is yet too early to say whether it is the intention of the syndicate to use the rights acquired by them for the manufacture of commercial machines or in military interests.

The convincing nature of the army tests carried out at Fort Meyer with the other Wright machine, of which a description appears on another page, has led the U.S.A. Navy Department to undertake a serious investigation as to the possibility of using such machines for scouting purposes at sea.

Although this introduces a further difficulty in the shape of providing an efficient substitute for the skids used in starting the apparatus, it is, however, not regarded as insurmountable by the American authorities, and it will not be putting our optimism to any very great test in contemplating the spectacle of a mechanically-propelled aëroplane co-operating with battleships and cruisers in future naval manœuvres.

It is true that the success so far achieved has been based upon fair weather conditions; what will be the behaviour of the machine in anything more than a moderate breeze remains to be seen. Improvements in design, increased power and stability may do much to overcome any difficulties in this direction, but it is probable that skilful manipulation will prove the more important element making for successful operation in a wind.

The success achieved by the brothers Wright as compared with Continental investigators appears to be due less to theoretical considerations than to the patience they have displayed during the ten years or more that they have occupied themselves with gliding experiments, and by which they were undoubtedly led to the important and crucial discovery of the effect on speed and lateral stability due to changing the angle of the lateral surfaces of the main planes by warping, and of the value of continuing the planes in rear of the rigid supports in the form of flexible leaves or surfaces. Other features making for success appear to consist in the adoption of the slow-running engine and correspondingly large propellers, in contradistinction to the high-speed engine and small propellers employed by French experimenters.

Although from the point of view of construction the Wright machine is far from realising the ordinary idea of an engineering "job," and falls far behind the refinements adopted in the French machines, it has nevertheless proved its radical superiority over the latter, both in its ability to accomplish flights of longer duration and in its weight-carrying capabilities, and has established a confidence in dynamic flight not dreamt of a year ago.

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Modern Locomotive Construction.

By J. G. BARWICK SAMS.

III.

We will now consider the running parts. The slide bars are bolted up to the cylinders and to the motion plate as mentioned above, by turned bolts. The bottom bars are bolted up first, and if the engine be horizontal, the spirit level can be used without any angle gauge, but more often the engine has a slope in order to clear the leading axle, in which case an angle gauge, cut to the required angle, will be necessary. The bottom edge of this gauge rests on the bar, while the top edge should be horizontal if the inclination of the bars is correct, and the spirit level can be tried on the top edge. If the inclination be wrong either one or the other end must be raised by inserting a brown paper liner between the bar and the lug, but this is seldom necessary. A block, similar to the crosshead, that has been machined to the standard size for the crosshead is used to set the top bars to; the block should be movable when the top bars are bolted up, with a little effort, and it should be tighter a little at the cylinder end than at the other end, as the cylinder end will open out a shade when hot.

After the bars are set, the proper crossheads may be tried in, and if tight may be eased by scraping some white metal off, but very little scraping ought to be needed, and the crossheads should not be too slack; if they can just be moved by hand, it will do very well.

The pistons are now put in, and the rods screwed up to or cottared up in the crossheads, care being taken that the stuffing box glands be put on first as they will not pass over the crosshead; after which the cylinder covers may be screwed up. In order that the clearances at each end may be measured, the fouling point of the piston and cylinder cover is found by pinching the crosshead sharply back with a wooden lever till the piston audibly "bumps" the cover; this is done for each end and for each piston, and the fouling point marked by scribing a line on the edge of the crosshead and on the edge of the slide-bar to correspond. This process is usually termed "bumping," and must be done before the connecting rods, &c., are coupled up.

In putting in pistons, the ports must be bridged across, otherwise the spring rings will jump into the port opening as the piston is going in and jam against the edges.

WHEELS.

The wheels now merit our attention. The axle boxes must be tried up in the horns, which are of course riveted up in position on the frames as mentioned before.

One face of the axle box is always white-metalled and planed up, and if the box is too tight in the horns a sharp scraper is used to pare the white metal down a little. The box must not be tried for tightness until the distance piece is put into the bottom of the horns and bolted up tight, and then it should only be movable by a steel tommy-bar about 2 ft. long.

The distance piece or "thimble" acts as a stay to the gap in the frames, and by tightening up the bolt through it, it tends to seize the box by closing the horns in. After getting the boxes correct in the horns they are dropped out and are now bedded on the axle journals by scraping and filing, as also

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are the connecting rod crank pin brasses. The eccentric straps are bolted together in position and tried also, and a brown paper or tin liner inserted if they be too tight, and if too slack, the straps must be filed where they butt together to let them up a bit. The axle boxes should bear fairly on the axle with no side rock, and the marking should show that the step is well down on the journal; the same remarks applying to the connecting rod brasses, which must be held together for trial purposes in some kind of a frame, as if they are put in the connecting rod to try it becomes almost too awkward on account of its size; and if they are not tightly held together in the frame when trying, hot brasses will result when they are tight in the rod-end, as they will pinch the journal. A good fit for brasses and eccentric straps is when they will swing round by hand and no "lift" is apparent.

The engine is now prepared for wheeling. The springs are mounted in their clips, which are hinged to the frame and the spring-pillars inserted through the top of the horns ready to bear on the top of the axle boxes. The wheels are brought down complete with boxes, brasses, &c., and put on the road just in front of and behind the engine in order. The cranes (one at each end) pick up the engine, and the wheels are rolled underneath, the axle boxes uprighted and the word given to lower away. A man at each box guides it into the horns, and if a box cants the word to stop must be instantly given, otherwise the canted box will hold one side of the engine up, and the other side being lowered off, gives an opportunity for a grave accident, which has happened before now, resulting in deaths and injuries through the engine falling sideways.

As the engine is lowered the spring-pillars will rest on the top of the boxes, and bearing at the other end against the various springs, will cause the engine to be spring-borne. The thimbles or distance pieces are put in place at the bottom of the horns and the bolts and nuts screwed up tight and split pins inserted. One end of the engine is now lifted, say the trailing end, having first put packing between the top of the horn block and the top of the box in order that all the weight should not come on to the springs, the wheels are pulled round till the crank pins are fair, when the coupling rods are put on and their retaining washers fastened up.

All the valve motion and connecting rods may be now put in and coupled up for trying the valves, which is done as follows:

Standard templates (Fig. 10) are prepared of the faces of the ports and of the valves. The port template is bolted to the cylinder-front in line with the valve travel, while the valve template is fixed to the end of the valve spindle (the covers being off the steam chest). If the engine be now pinched till the port be uncovered by the valve, say $\frac{1}{4}$ in., and if we set the two templates so that they show a similar opening, we know that the valve template bears the same relation to the port template as the actual valve does to the port.

FINDING THE DEAD CENTRES.

The dead centres must now be found. If the engine be pinched along until the crank pin very nearly approaches the dead centre, and a mark be made on the crosshead and on the guide bar to correspond; also by means of a trammel, a mark be made on the driving wheel tyre (Fig 11) to cut a line drawn down the

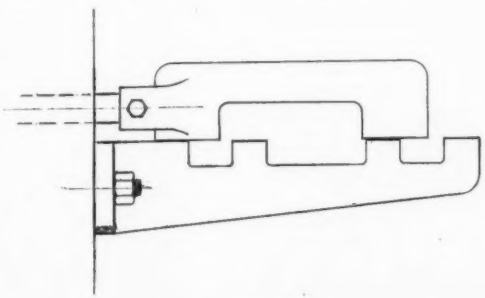

FIG. 10.

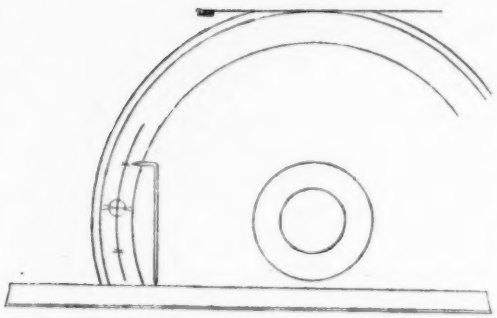

FIG. 11.

middle of the tyre parallel to its edges, and a centre dab put at the point of intersection; now the engine is pinched along a bit more until she has gone over the dead centre and the marks on the crosshead and guide bar again exactly correspond; when the trammel is used again to scribe a line to cut the centre line of the tyre and another centre dab put; and if now the distance between these two dabs be bisected on the centre line, and the engine pinched along until the trammel point coincides with point of bi-section and stopped there, the crank on which we have been working will then be on its absolute dead centre, and the lead of its valve may be measured on its templates. The other three dead centres and leads are found in the same way, and the valves corrected as follows:—

Suppose we want a total lead of $\frac{1}{4}$ in., *i.e.*, $\frac{1}{8}$ in. at each end; if the leads we have taken when added up equal this sum, we know that the eccentrics are right, but suppose although they add up right the amount is unequally distributed, say that we have too much lead at the front end, all that we have to do is to halve the inequality and lengthen the eccentric rod that much; if too little lead at front end, shorten the rod, &c. If they do not add up to the right sum the eccentric must be put on if the amount is too little, or put back if the amount is too much.

When setting, it is usual to run the reversing gear in to about half way between maximum travel and mid-gear, so as to nearly approximate running conditions; and the back gear as well as the forward gear should be tried over. Also, when setting radial gears the boiler must be filled with water to its working level, and if a tank engine, the bunker must have its equal quota of coal in it so as to bring the engine down on its springs to its working level, as any vertical alteration in position affects radial-driven valve travel very considerably, and if the gear be set right for an engine without its coal and water it will be all wrong when the coal and water are put on board.

While each side is on its dead centres the distance between the mark on the cross-head and the fouling mark can be measured for each end of each engine stroke, and that gives us the clearance. If not correct, the piston rod must be shortened or replaced by a longer one, as the case may be.

The templates may now be removed and the steam chest covers, buffer plank and buffers put on and screwed up. The blast pipe is bolted into place, care being taken to get it exactly central with the chimney by means of a straight-edge passed down the chimney and held against the wall of the chimney in various positions, and measuring from it to the blast pipe centre. If the pipe is not central, it must be chipped to throw it over sufficiently.

All the small gear can now be adjusted, rods for working the sand valves, cylinder cocks, &c., various lubricators, name and number plates, safety valve, whistles, steam gauges, injectors, &c., &c. The brake gear is fitted and adjusted by screws in the draw gear so that each block bears fairly against its wheel when the brake be applied.

If the vacuum or Westinghouse brakes be fitted, the pipes, &c., must be tested in position by water pressure to $1\frac{1}{2}$ times the working pressure, say 24 lbs. per sq. in. for vacuum pipes, and 150 lbs. for the air-brake pipes.

Also piping for the steam heating of carriages is needed on passenger engines. The steam for this is controlled by a valve on the boiler and immediately after the stop valve passes through a reducing valve to bring its pressure down to 60 lbs. per sq. in., and the piping for this also requires testing to 1½ times its pressure, *i.e.*, 90 lbs. A safety valve on this heating pipe should be provided, also a pressure gauge to indicate the pressure delivered to the train.

The engine is now given a coat of lead colour paint and coupled to its tender, all pipe connections, &c., being made good.

A New Development in Squared Paper.

By H. HESS.

The author describes* an application of squared or logarithmic paper which possesses some features of interest. The method has been found valuable in his own work. The logarithmic chart has also been dealt with by Mr. J. Goudie,† to which readers interested in the subject are referred.

THE following paper is confined to one phase of the subject, viz., that relating to the graphic derivation of an expression, law or formula, defining the quantitative relationship of plotted observations.

Of squared paper, two types are more or less in general use; that shown in Fig. 1 has equal spacing, and will hereafter be referred to as "plain"; the other, Fig. 2, has logarithmic spacing, to be hereafter referred to as "logarithmic."

The improvement is in both forms, and is shown in both figures by the addition of certain scales at the top and right sides. This scale starts with 1 at the upper right corner, and then runs down by even dimensions as 0·9, 0·8, 0·7, &c., to 0 at the left top corner and right bottom corner. These scales make possible, without resort to calculation, the ready and graphic determination of certain constants in a formula that is sought.

The terms used herein are, wherever possible, such as the ordinary draughtsman or mechanic would employ, rather than the technical expressions of the mathematician; the latter will have no trouble in following these even though he may not approve them, considering his terms shorter and more precise: a contention that may be granted, but that will not help the man with the other training.

Equations expressing the relationship of two quantities are, as far as observations in the domain of an average engineer's experience are concerned, chiefly in the form

$$A = \pm y B^{\pm x} \pm z$$

The top and right hand scales facilitate the determination of the values of y and x.

As long as the expression involves the first power, or $x = 1$, the equation takes the form

$$A = \pm y B \pm z$$

A line expressing it will be a straight line when plotted on plain paper. Plain paper may therefore be logically employed in such case.

When, however, x has some value other than 1, whether larger or smaller,

* Proceedings Engineers' Club, Pa.
† *Eng. Rev.*, Vol. XIV., pp. 161-5.

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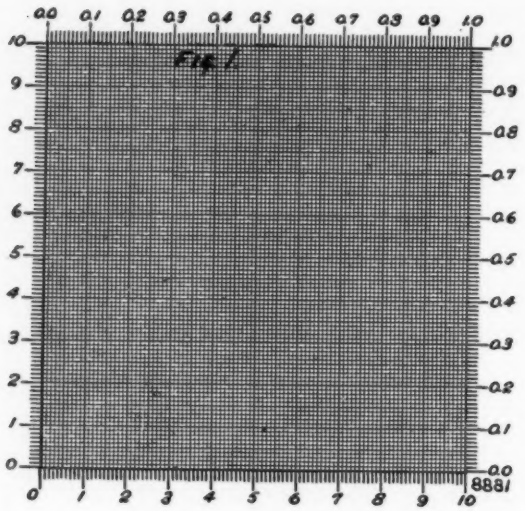


then the line expressing the relationship will be curved when the data are plotted on plain paper; if the data are plotted on logarithmic paper, the line will often be straight. If it is suspected that powers are involved, the data should therefore be plotted on logarithmic paper; if plotting on plain paper gives a curved line, replotting on logarithmic paper will be advisable. In the following presentation, mathematical reasoning will be avoided and the various lines that show the character of the relationship of the observations, hereafter termed "characteristics," will be explained by taking up each in turn.

PLAIN PAPER STRAIGHT LINE CHARACTERISTICS.

In Fig. 3 the characteristic starts at the left bottom zero or origin, and proceeds diagonally to the top right hand corner and scale value 1. We know it to be expressed by the general equation

$$A = \pm yB \pm z$$

Whenever the characteristic starts from origin 0, that means that $z = 0$. Whenever the characteristic starts from origin 0 and meets or intercepts the top scale at 1, that means that $y = 1$. Whenever the characteristic trends from left to right upward we know that y is $+$. Therefore for characteristic we have

$$A = +1\,B \pm 0, \text{ or } A = B$$

In Fig. 4 the characteristic has its origin on the left scale; the value of the intercept gives z; in this case 4. To get the value of y, a parallel line to the characteristic is dotted through 0 as the origin. This parallel may be termed the secondary characteristic, or shortly, the "secondary." The intercept of this secondary with the top scale gives the value of y as in Fig. 1. Therefore we have for the characteristic

$$A = B + 4$$

In Fig. 5 the characteristic is similar to that of Fig. 4, differing only in not intercepting the left scale; we therefore prolong it to intersection with the prolongation of the left scale.

Whenever the characteristic prolonged intercepts the prolongation of the left scale below zero, the value of z will be given by the intercept, but z will be minus. In this case therefore

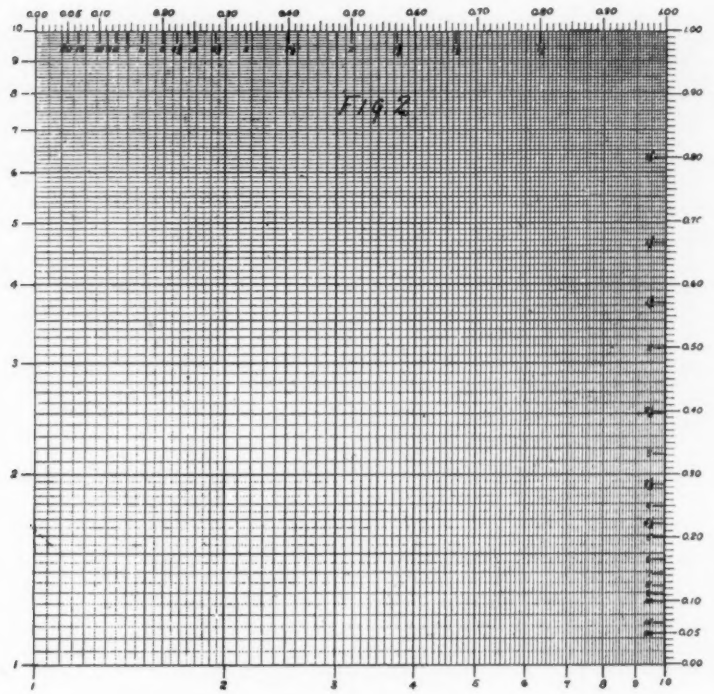
$$z = -4$$

Nothing in the secondary as described for Fig. 4 shows $y = 1$. We therefore have

$$A = B - 4$$

In Fig. 6 the characteristic trends from left to right, but downward instead of upward. Whenever the characteristic runs downward from left to right, y is minus. As before, z is given by the intercept with the left scale, in this case at 10, so that $z = 10$. To determine y, the secondary must be drawn in.

Two methods are available. The one preferred by the writer starts y at the left bottom origin 0 at the same angle upward to the right as the primary characteristic trends downwards. The intercept with the top and right scale



gives as before $y = 1$. From this we get

$$A = -B + 10$$

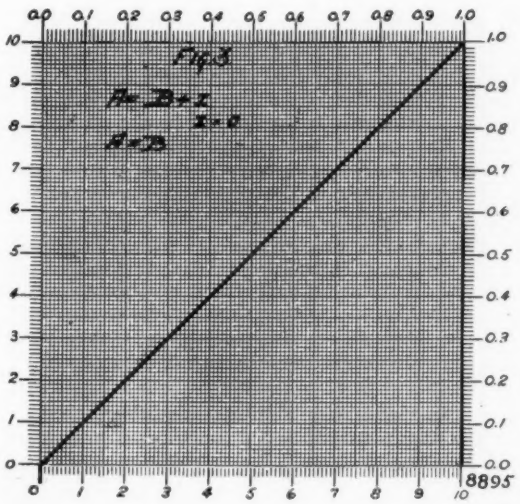
In Fig. 7 the left to right downward trend again indicates that y is minus and the intercept with left scale gives $Z = 4$; the secondary again shows $y = 1$, so that

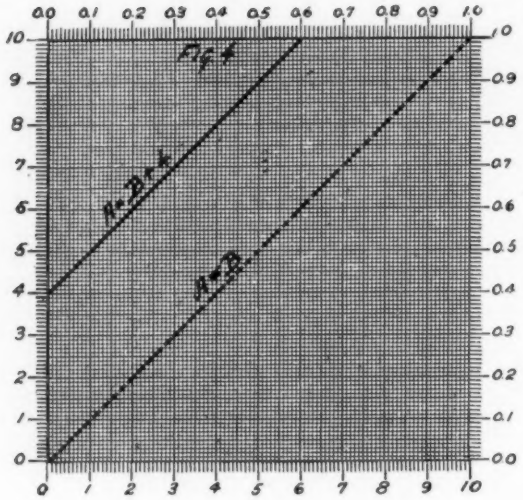
$$A = -B + 4$$

In Fig. 8 the characteristic prolonged intercepts the left scale prolonged at 14, giving $z = 14$, and the secondary shows $y = 1$, while the left to right downward trend of the characteristic gives y as minus, so that

$$A = -B + 14$$

Fig. 9 differs from Fig. 3 only in the intercept of the





characteristic with the top scale being at 0·4 instead of at 1. This intercept gives the value of y. The top scale might be made to read y directly, but its divisions would then not be even, and interpolations for fractional values consequently difficult. Indeed, the evenly divided scale is used; with that y is the reciprocal of the scale value. Whenever the characteristic or its secondary intercepts the top scale, the value of y is greater than unity. In this case the intercept is at 0·4, so that $y = \frac{1}{0{\cdot}4} = 2{\cdot}5$.

The other quantities are determined as in connection with Fig. 3; therefore,

$$A = 2{\cdot}5\,B \pm 0 \qquad A = 2{\cdot}5\,B$$

Fig. 10 gives y + and $z = +5$, as before explained. To get y quantitatively, dot in the secondary from 0 and find that it intercepts the top scale at 0·4, whose reciprocal 2·5, is y, so that

$$A = 2{\cdot}5\,B + 5$$

In Fig. 11 the prolongation of the characteristic with the prolongation of the left scale gives $z = -12{\cdot}5$. As before, we get

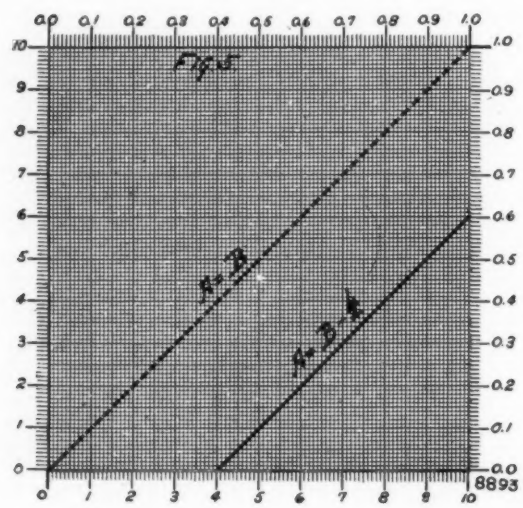
$$A = 2{\cdot}5\,B - 12{\cdot}5$$

Fig. 12 has the characteristic trending downward from left to right, which means that y is minus. Proceeding as before gives

$$A = -2{\cdot}5\,B + 10$$

Figs. 13 and 14 will be clear from the preceding.

Fig. 13. $A = -2{\cdot}5\,B + 25$
Fig. 14. $A = -2{\cdot}5\,B + 25$



In Figs. 15 to 20 the characteristics lie at a lesser inclination with reference to the horizontal; the characteristic or its secondary intercepts the right hand scale instead of the top scale. Whenever the secondary intercepts the right hand scale, the value of y is less than 1; that value is directly read at the intercept.

With this and the preceding explanations the equation for these Figures will be clear

without further detailed explanation. They are:

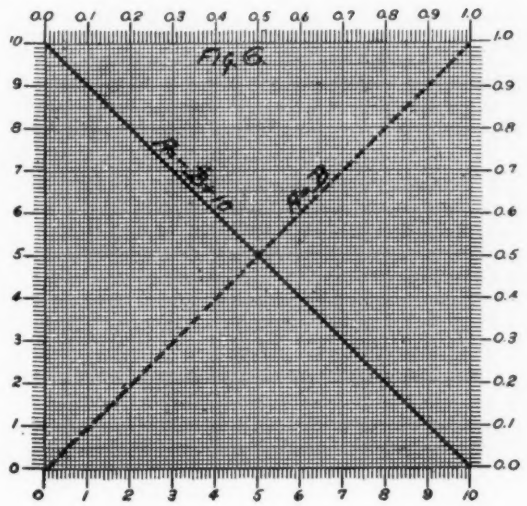
Fig. 15. $A = 0{\cdot}4\ B$
Fig. 16. $A = 0{\cdot}4\ B - 2$
Fig. 17. $A = 0{\cdot}4\ B + 2$
Fig. 18. $A = 0{\cdot}4\ B + 10$
Fig. 19. $A = 0{\cdot}4\ B + 12$
Fig. 20. $A = 0{\cdot}5\ B + 2$

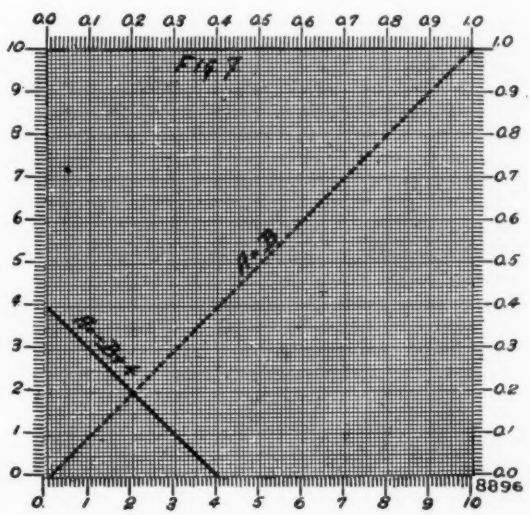
By comparing Figs. 5, 11 and 16 it becomes clear why the value of z must not be taken at the intercept of the characteristic with the bottom scale, but at the intercept of the prolongation of the characteristic with the prolongation of the left scale. An apparent exception is found in Fig. 5, but that is apparent only, and due to the fact that the inclination of a primary characteristic whose secondary intercepts the top scale at 1 intercepts the bottom and the left scale (prolonged) at the same values; for other inclinations these intercepts are at different values.

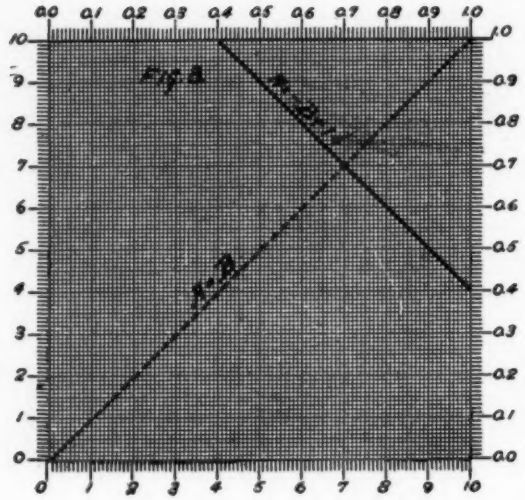
It is sometimes convenient to assign different values to the left and bottom scales; in other words, to make these of different lengths.

Fig. 21 shows how this affects conditions. The top and right scales are again the new scales of even parts, but the characteristic $A = B$ now has an inclination from left to right that is more nearly vertical that 45 deg. Fundamental difference there is none. As it is more convenient to use paper that has the values of the top and right scales printed, and as it would be impracticable to have such paper in all of the possible variants of the relative right and bottom scale values, it will be better to use a constant multiplier for one or other scale and so permit the use of the prepared paper.

In connection with Fig. 6 it was mentioned that the secondary might be dotted in two ways; the one preferred was used. The other way is to always draw the secondary parallel to the primary characteristic; when the latter trends from left to right downward the



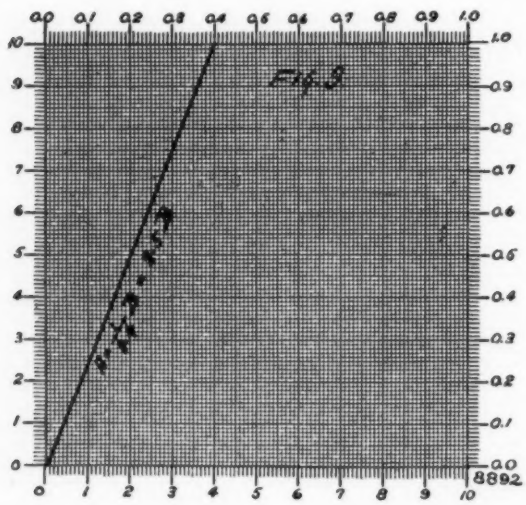




right scales will have a different value, o being at the upper right as shown in Fig. 22 with an example

$$A = -0{\cdot}75\,B + 14{\cdot}5$$

As this required two sets of values for the top and right scales, the first method described with Fig. 6 is to be preferred.



PLAIN PAPER STRAIGHT LINE CHARACTERISTICS. RÉSUMÉ.

General equation $A = \pm y\,B \pm z$

The primary characteristic is the line drawn through the observed values.

The secondary characteristic is a line drawn parallel to the primary, but passing through the left bottom zero. Whenever the primary has an inclination from left to right downward, the secondary passes through the left bottom zero from left to right upward at the same inclination to the horizontal as the primary.

$y = 1$ when the secondary intercepts the top or right scale at 1.

$y > 1$ when the secondary intercepts the top scale; its quantitative value is the reciprocal of the top scale intercept.

$y < 1$ when the secondary intercepts the right scale; its quantitative value is read directly from the scale intercept.

y is + when the characteristic rises from left to right.

y is — when the characteristic drops from left to right.

z has a quantitative value given by the intercept of the characteristic with the left scale, or of their prolongations.

z is + when the intercept is above o.

z is — when the intercept is below o.

LOGARITHMIC PAPER CHARACTERISTICS.

Logarithmic paper differs from plain paper only in the divisions being proportional to the logarithms of the number instead of proportional to the numbers themselves. For present purposes a familiarity with this paper is assumed.

Fig. 2 is a sheet of logarithmic paper differing from the ordinary only by the addition of the top and right scales of even divisions marked 1, 0.9, 0.8, &c., to 0. These correspond to those

described in Figs. 3 and 9 for plain paper; but whereas with plain paper these new scales served to find the value of the coefficient y, they now serve to find the value of the exponent x.

The general equation referred to before

$$A = \pm y B^{\pm x} \pm z$$

is conveniently handled by logarithmic paper, and gives straight line characteristics whenever

$$z = 0$$

It is clear at once that all of the relations of Figs. 3, 6, 9, 12, 15 and 18 which correspond to

$$A = \pm y B^{\pm x} \text{ with } x = 1$$

can be plotted on logarithmic paper as well as plain.

This being so, it would be logical to always plot data on logarithmic paper, because this covers far more ground than does the plain; unless indeed it were known that the relations correspond to

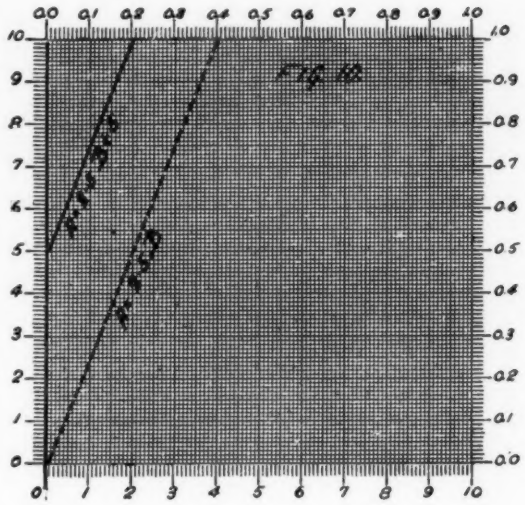
$$A = \pm y B \pm z$$

To avoid the multiplication of figures, and as the proceedings are analogous to those explained in detail for plain paper, a number of characteristics are shown in Fig. 23, each marked with a Roman numeral.

The characteristic I. starts from the origin 1 at left and bottom and intercepts the top scale at 1. This gives x as 1, or shows that the first power of B is involved.

As the characteristic trends from left to right upward, this shows that B is the numerator of a fraction whose denominator is 1.

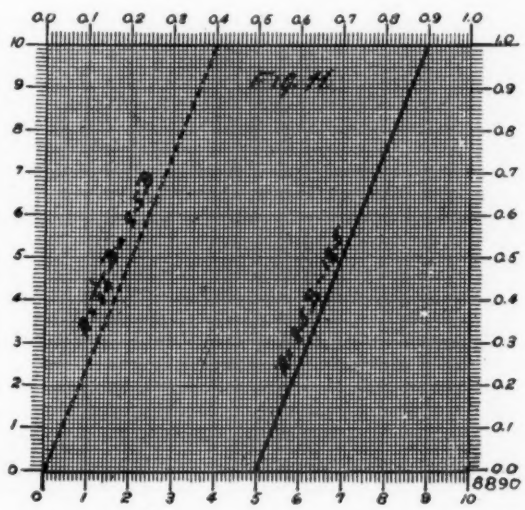
As the characteristic intercepts the left scale at 1, this makes $y = 1$.

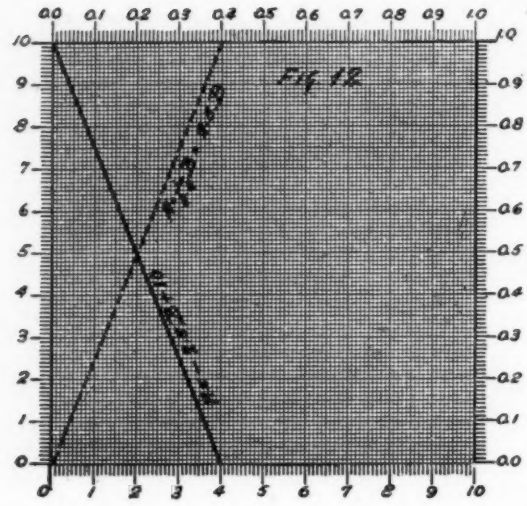


We have therefore

$$A = 1 \frac{B^1}{1} \text{ or } A = B$$

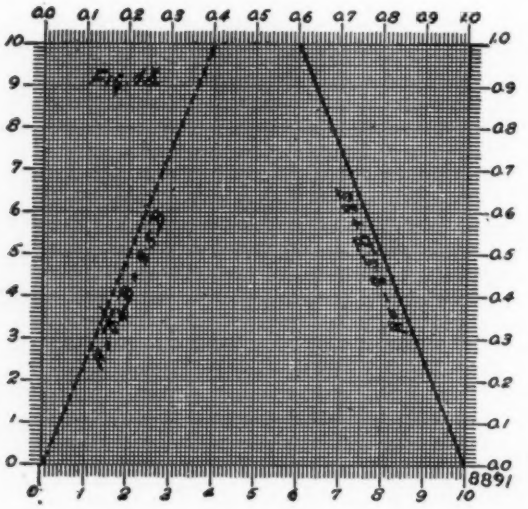
The characteristic II. intercepts the left scale at 4, giving that as the value of y. The secondary parallel to the





characteristic starts at left bottom 1; it coincides with I.; this shows the exponent is 1, and the trend shows, as before, that B is $\frac{B}{1}$; this gives

$$A = \frac{4}{1}\frac{B}{1} \text{ or } A = 4\,B$$



The characteristic III. (prolonged) intercepts the left scale (prolonged). Instead of prolonging the left scale, it will be convenient to dot in a second leg of III., starting at the top vertically above the intercept with the bottom scale, in the manner usual with logarithmic paper, the second leg paralleling the first. The intercept of this line III. a, with the left scale is at 2·5. As this is really the intercept of the prolongation of the left scale, which prolongation has values one-tenth those of the scale, the intercept value is 0·25, so that $y = 0{\cdot}25$.

The characteristic IV. trends from left to right downward; this means that B is the denominator of a fraction whose numerator is 1, or, expressed otherwise, the exponent x is minus.

The exponent is found, as before, by drawing in the secondary from left bottom 1 upward at the same inclination from the horizontal as the primary. This secondary coincides with I., so that we know B is of the first power.

As the primary intercepts the left scale at 10 we have $y = 10$ and the total

$$A = \frac{10}{1}\frac{1}{B} \text{ or } A = 10\,B^{-1} \text{ or } A = \frac{10}{B}$$

The characteristics V. and VI. are similarly found to respond to

V. $A = \frac{4}{1}\frac{1}{B}$ or $A = 4\,B^{-1}$ or $A = \frac{4}{B}$

VI. $A = \frac{40}{1}\frac{1}{B}$ or $A = 40\,B^{-1}$ or $A = \frac{40}{B}$

The intercept of VI. (prolonged) with the left scale is found by dropping the intercept at the top to the bottom

and paralleling the characteristic to intersection with the left scale; it so happens that this coincides with line V. The intercept is at 4, but as the actual first intercept is above the scale, this value must be multiplied by 10, giving 40. Had it been necessary to draw in a second prolongation, in case the first did not intercept the left scale, then the multiplier would have been 100. In other words, each prolongation to final interception with the left scale multiplies the scale value by 10, if the true intercept falls above the scale; if that falls below the scale each multiplier becomes a similar divisor.

When, in the equation:

$$A = y\,B$$

$y = 1$ and $z = 0$ we have

$$A = B$$

Whenever the plotted values lie along a straight line characteristic that starts from the left bottom at 1, such characteristic responds to this equation. It remains only to determine the value of the exponent x.

It is here that the new top and right scales come in by making the determination of x a mere matter of reading the scale; such determination will be as simple when x is a compound fraction, as $1\frac{1}{3}$, as for the square, with $x = 2$.

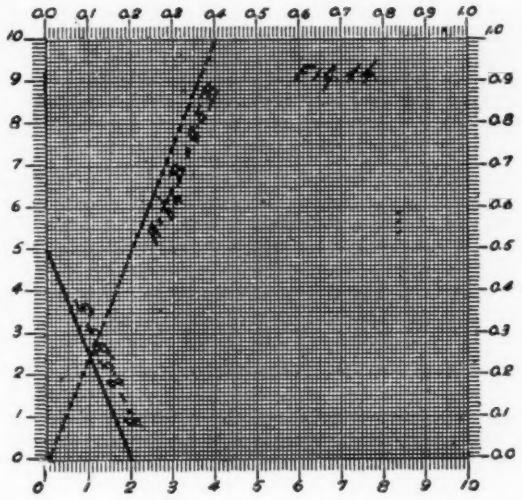
Whenever the characteristic intercepts the right scale the scale reading of the intercept is the power sought, and such power is less than 1.

Thus characteristic (Fig. 24):

I. intercepts right scale at 0·2 and $A = B^{0\cdot2} = B^{\frac{1}{5}} = \sqrt[5]{B}$

II. intercepts right scale at 0·333 and $A = B^{0\cdot333} = B^{\frac{1}{3}} = \sqrt[3]{B}$

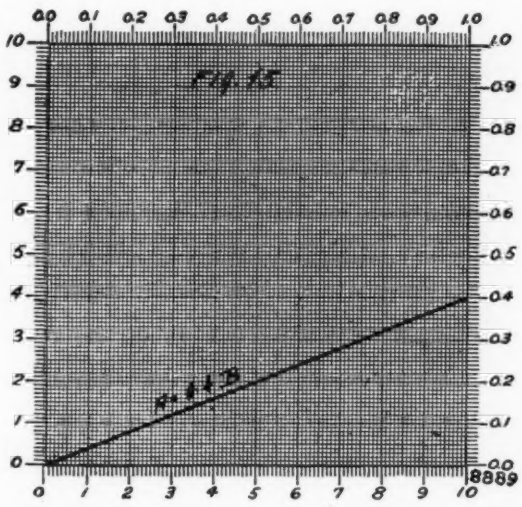
III. intercepts right scale at 0·4 and $A = B^{0\cdot4} = B^{\frac{2}{5}} = \sqrt[5]{B^2}$



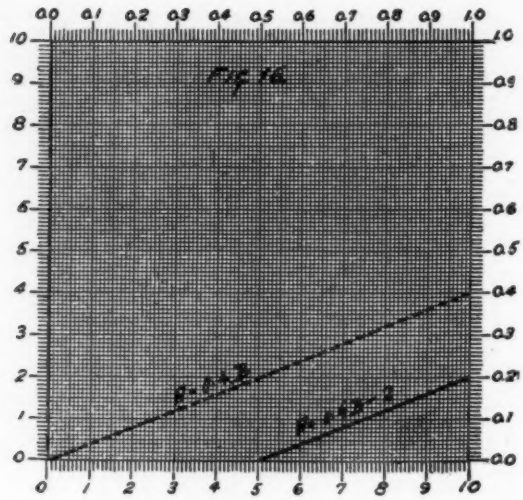
IV. intercepts right scale at 0·5 and $A = B^{\frac{1}{2}} = \sqrt{B}$

V. intercepts right scale at 0·666 and $A = B^{\frac{2}{3}} = \sqrt[3]{B^2}$

VI. intercepts right scale at 0·75 and $A = B^{\frac{3}{4}} = \sqrt[4]{B^3}$



XUM



The characteristic intercepting the junction of top and right scales at 1 on scale gives

VII. $A = B^1 = B$

Whenever the characteristic intercepts the top scale, the reciprocal of the scale reading of that intercept is the power sought, and such power is greater than 1. Thus characteristic

VIII. intercepts top scale at 0·75 and $A = B^{\frac{1}{0.75}} = B^{\frac{4}{3}} = \sqrt[3]{B^4}$

IX. intercepts top scale at 0·666 and $A = B^{\frac{1}{0.666}} = B^{\frac{3}{2}} = \sqrt{B^3}$

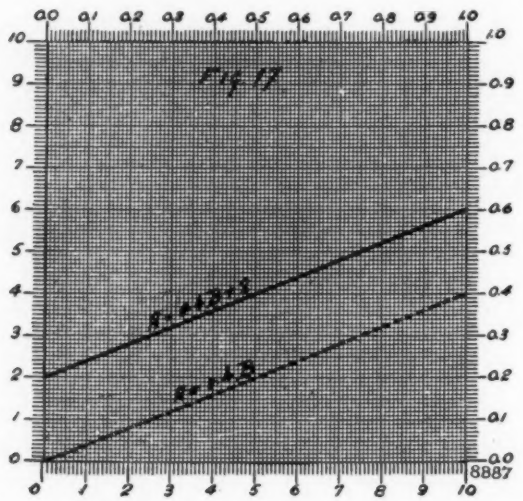
X. intercepts top scale at 0·5 and $A = B^{\frac{1}{0.5}} = B^2 = B^2$

XI. intercepts top scale at 0·4 and $A = B^{\frac{1}{0.4}} = B^{\frac{5}{2}} = \sqrt{B^5}$

XII. intercepts top scale at 0·333 and $A = B^{\frac{1}{0.333}} = B^3 = B^3$

XIII. intercepts top scale at 0·2 and $A = B^{\frac{1}{0.2}} = B^5 = B^5$

The determination of the lower whole powers, such as the square and cube or the corresponding roots, is a relatively simple matter by a trial calculation or two. The determination of such a relatively frequent exponent as $\frac{2}{3}$ or $\frac{3}{2}$ is by no means simple unless such value is expected, and even proof calculations entail much more trouble than does the use of these top and right scales. With these scales, on the other hand, a fractional power such as 0·666 or 1·333 is no more difficult than the simplest powers, as the square or cube or the corresponding roots.



Characteristics XIV. to XVI. of Fig. 24 correspond to the general form.

$$A = \pm y B \pm x$$
$$A = \pm y B \pm x = z$$

with $z = 0$, so that

By the method of section 27, $y = 10$.

As the trend of the characteristics is, downward from left to right x is minus, giving us

$$A = 10 B - x$$

The value of x is determined by drawing in the secondaries that in this case correspond to characteristics

III., IV., and X., giving $x =$ 1, 0·5 and 2, so that

XIV. is $A = 10\,B^{-1} = \frac{10}{B^1} = \frac{10}{B}$

XV. is $A = 10\,B^{-0.5} = \frac{10}{B\,0.5} = \frac{10}{B^{\frac{1}{2}}} = \frac{10}{\sqrt{B}}$

XVI. is $A = 10\,B^{-2} = \frac{10}{B^2}$

Fig. 25 contains a group of characteristics again corresponding to the general form,

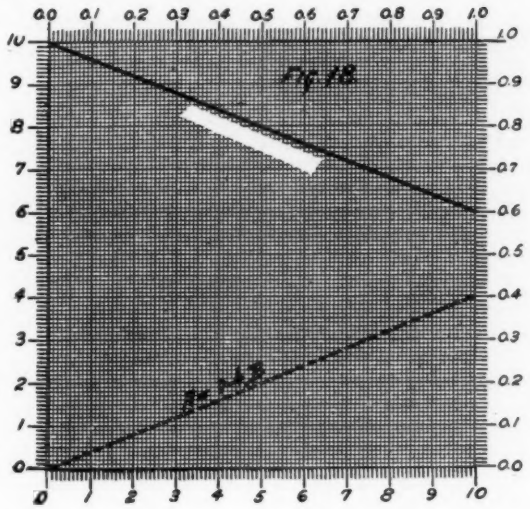
$$A = \pm B^{\pm x} \pm z$$

but that have values for z other than 0.

Reversing the process of finding the expression from plotted data, take the dotted secondary I.

This is $A = B$. Adding $z = 1$ gives characteristic II.

$$A = B + 1$$



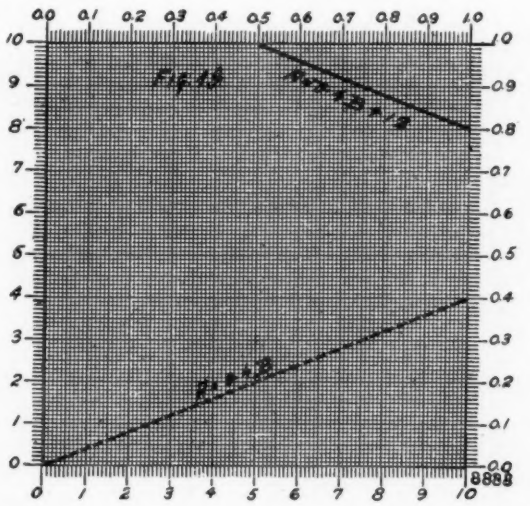
In adding z, the logarithmic scale value of z corresponding to that portion of the paper in question must be taken, so that with the logarithmic paper the characteristic becomes a curve. On plain paper (section 9) with B in the first power, the characteristic was a straight line. To formulate observations which, plotted, give the characteristic II., the first proceeding is to draw a secondary from the left bottom 1 to the right top 1; if inspection at two points shows that to be an equal amount below the characteristic, such amount is z.

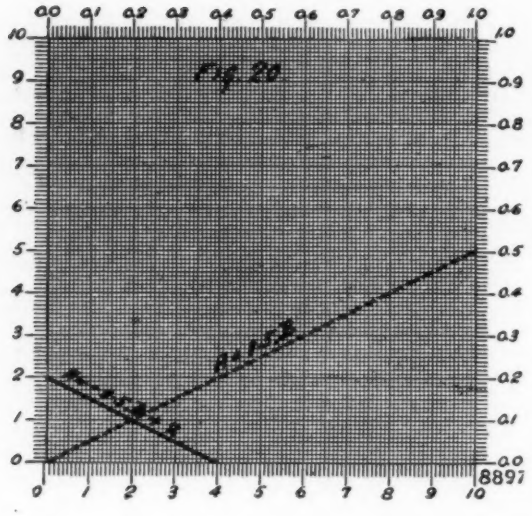
It must not be overlooked that it is not the scale value of the intercept at the left which equals z, but the distance between the characteristic and its secondary; this is the vertical difference between any two points.

Characteristic III., $A = B - z$, differs from II. only in lying below its secondary I. by the amount z, so that z is minus.

The determination of the sign + or − for z is simply by mere inspection; if the characteristic is above its secondary, z is +; if the characteristic is below its secondary, z is −.

Characteristic IV., plotted through





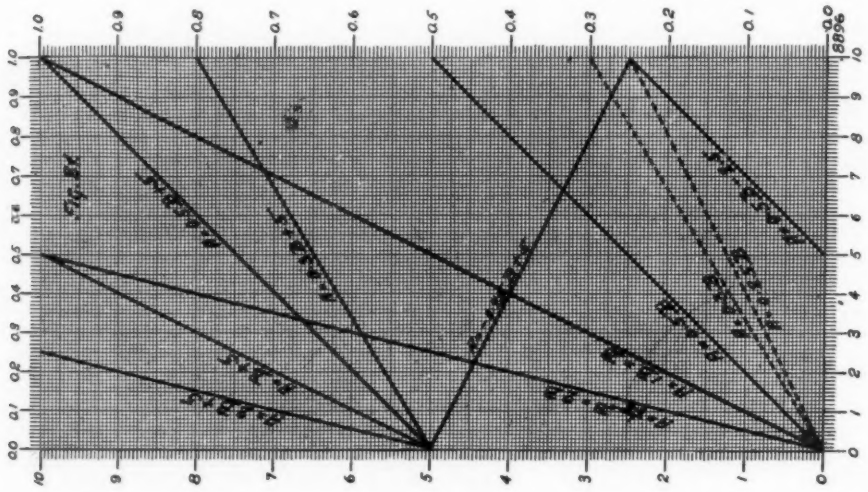
observed data, is assumed by inspection to be of the general form

$$A = \pm y B^{\pm x} \pm z$$

Mere inspection shows (characteristic above its secondary) that z is $+$; inspection also discloses, since the trend is upward from left to right, that x is $+$. The values of y, x and z remain to be found. The simplest assumption is that $x = 1$. In that case the dotted I. would be the secondary; also I. would be equidistant from IV.; examination shows that at the left scale the difference between IV. and I. is $5 - 1 = 4$, while over 3 on the bottom scale this difference is $9 - 3 = 6$; as these differences are not equal, our assumption was incorrect. Still working along the simplest lines, we will assume that x is still 1, but that the y is some value larger than I. Then moving a 45-deg. triangle upward gives a position at which the differences z are equal; in this case $z = 3$ for the secondary VI. This straight line secondary is $A = y B$ with $y = 2$ from its intercept with the left scale. This gives us

$$A = 2 B + 3$$

Characteristic V. is similarly found to be $A = 2 B + 1$.



Characteristic VII., being below its secondary, gives z as minus. Proceeding by trial as above gives the secondary VI.

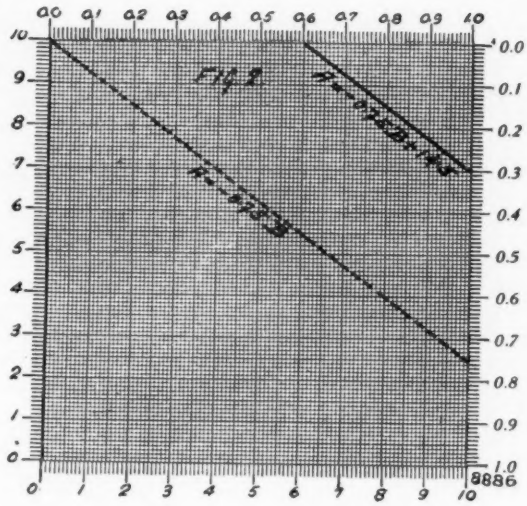
$A = y\,B$ at distance $z = 3$; as $y = 2$ (by left intercept) $A = 2\,B$; the total for characteristic VII. is

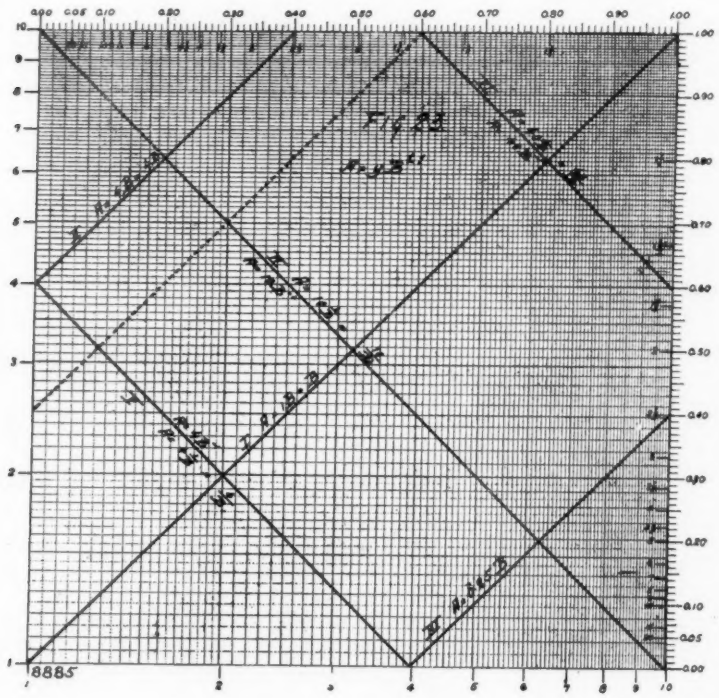
$$A = 2\,B - 3$$

Characteristic VIII., being above its secondary, gives z as $+$ and $= 1$. Proceeding by trial we get the secondary IX., which in the familiar way is resolved into

IX. $A = \frac{1}{2}\,B$, making
VIII. $A = \frac{1}{2}\,B + 1$

The method of forming continuations of these characteristics is of interest.





Take

$$\text{V. } A = 2B + 1$$

Continue first the characteristic VI., $A = 2B$, and get $-X$; by adding $z = 1$ to this we get

$$\text{XI. } A = 2B\,1$$

As this continuation is a second leg the scale values of the first part are increased tenfold, so that the distance that for the first section was 0·1 is now 1.

Characteristics XII. and XIII., trending from left to right downwards, show by inspection that the exponent x is $-$

XII., being above its secondary, shows that z is $+$ while XIII., being below, shows that z is $-$

Proceeding as before on the simplest assumption that $x = 1$, we get the secondary XIV. for both characteristics, and from its intercept with the left scale at 10 find $y = 10$; z was found by trial as being 2 above the secondary for XII. and 2 below for XIII., giving totals

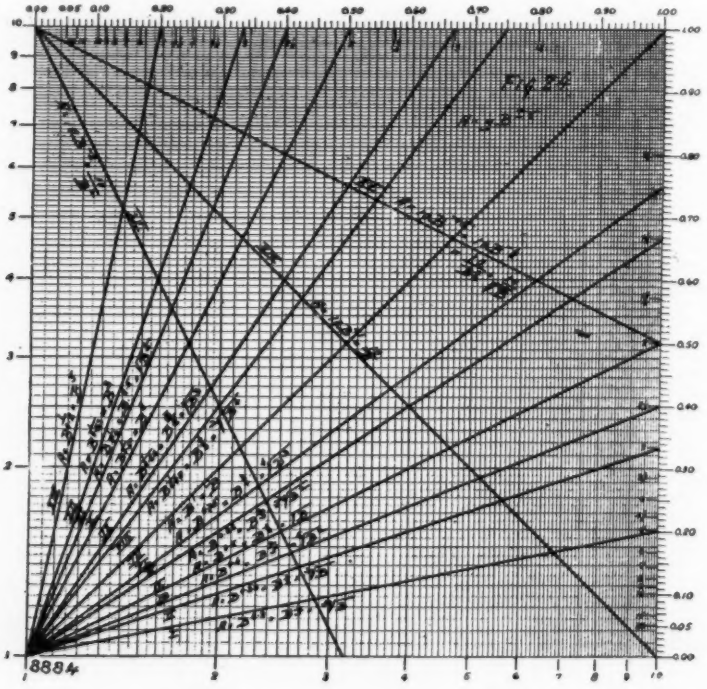
$$\text{XII. } A = y B^{-1} + z = \frac{10}{B} + 2$$

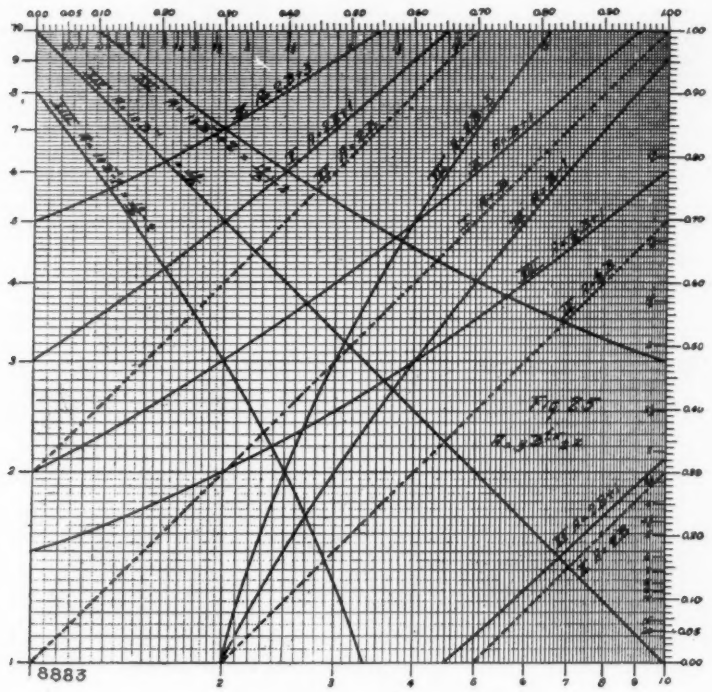
$$\text{XIII. } A = y B^{-1} - z = \frac{10}{B} - 2$$

Plotting a series of observations gives a characteristic I. on Fig. 26. We assume that this is still of the general form

$$A = \pm y B^{\pm x} \pm z$$

The elevation above secondary shows z is $+$; we therefore move a straight-edge round below the characteristic until a line II. is found that is equi-distant by the amount $z = 1$. This secondary has its origin in the left bottom 1 and intercepts the top scale at 0·5, showing that $x = \frac{1}{0{\cdot}5} = 2$; as the trend is from left to right upward, x is $+$.





This gives the secondary II. $A = B^2$, and the characteristic I.

$$= B^2 + 1$$

The characteristic III. is similarly determined as $A = B^2 - 1$, remembering that z must be $-$ since the characteristic is below its secondary.

Characteristics IV. and VI. are readily found to have the secondary V., whose exponent is given by intersection with the right scale as $x = 0{\cdot}5$ making

Secondary V. $A = B^{\frac{1}{2}} = \sqrt{B}$ and
Characteristic IV. $A = \sqrt{B} + \frac{1}{2}$
Characteristic VI. $A = \sqrt{B} - \frac{1}{2}$

The values of z were found as the difference between the characteristics and their secondary.

Characteristic VII. $A = 2\,B^2 + 1$
Secondary VIII. $A = 2\,B^2$
Characteristic IX. $A = \frac{1}{2}\,B^2 + 1$
Characteristic X. $A = \frac{1}{2}\,B^2 - 1$
Secondary XI. $A = \frac{1}{2}\,B^2$

are readily determined by the aid of the preceding explanations.

Characteristic XII. $A = 10\,B^2 - 1 = \frac{10}{B^2} - 1$

Characteristic XIII. $A = 10\,B^2 + 1 = \frac{10}{B^2} + 1$

Secondary XIV. $A = 10\,B^2 = \frac{10}{B^2}$

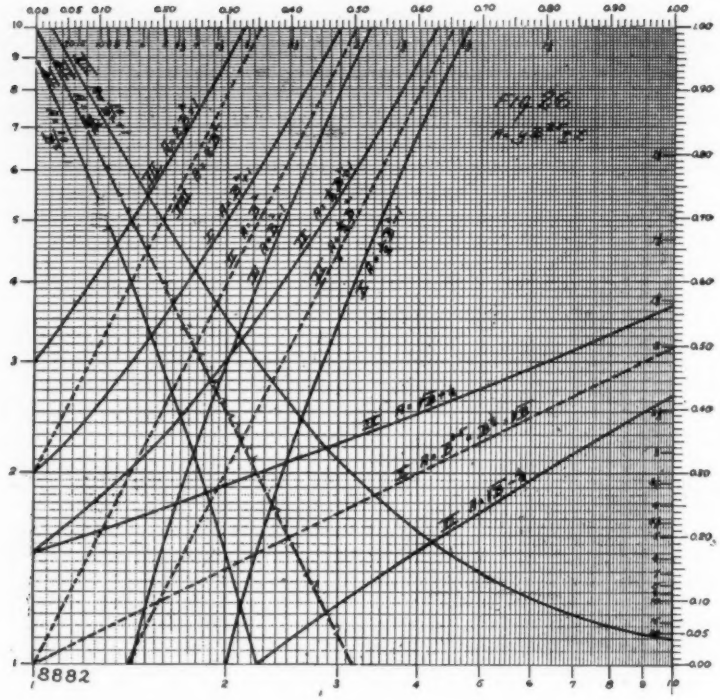
will be readily determined, remembering that the elevation of XIII. above its secondary establishes z as $+$ and the depression of XII. gives its z as $-$; also that the downward trend from left to right fixes x as $-$, while the value of x is fixed by the intersection of the secondary's complement II. with the top scale at $0{\cdot}5$, the reciprocal of which, 2, gives x.

RÉSUMÉ.

General Equation $A = \pm\, y\, B^{\pm x} \pm z$

If the plotted characteristic is a straight line $z = 0$, leaving

$$A = \pm\, y\, B^{\pm x}$$



If the plotted characteristic is a straight line trending from left to right upward, x will be plus; if downward, x will be —.

If the plotted characteristic is a straight line crossing the paper at an angle of 45 degs., x will be 1.

If the plotted characteristic is a straight line nearer the vertical, x will be greater than 1; if nearer the horizontal, x will be less than 1.

If the plotted characteristic is a straight line passing from left to right upward from the lower left origin, y will have the value of origin 1.

If the plotted characteristic is a straight line passing from left to right upward from the lower left origin 1, its intercept with the upper scale will be at a value that is the reciprocal of x; if the intercept is with the right scale, the intercept value will be x as a power; the reciprocal of x will be a root.

If the plotted characteristic is a straight line its intercept with the left scale will give y. If it does not intercept the left scale then the intercept of its prolongation with the prolongation of the left scale will give y. If such intercept is with the downward prolongation of the left scale, y will be less than 1; if with the upward prolongation, y will be greater than 1.

If the plotted characteristic is a straight line downward from left to right, then x will be —. Its value is found by drawing a secondary that runs upward from left to right through the lower left origin 1, at the same inclination from the vertical as the primary. This secondary will intercept the top or right scales and there give values of $\pm x$ (Section 37).

If the plotted characteristic is a straight line trending upward from left to right and intercepting directly or by prolongation the left scale at some value other than the lower left origin 1, then a secondary drawn through that origin and parallel to the characteristic will, by its interception with the top or right scale, give the value of $\pm x$.

If the plotted characteristic is a curved line, z will have a value other than 0. z will be + if the characteristic is above the secondary; z will be — if the characteristic is below the secondary.

If the plotted characteristic is a curved line, z will have a value the amount of which must be

found by drawing in a secondary. This may be done by manœuvring a straight-edge around on the convex side of the characteristic until a position is found which is equi-distant throughout (on vertical logarithmic scale) from the characteristic. This distance is z.

If the characteristic is a curved line, the value of z will be the vertical scale difference between the characteristic and its secondary.

The first secondary is that straight line which lies at equal vertical distances from the characteristic.

If the characteristic is a curved line, the value of y will be given by the intercept of its first secondary with the left scale.

If the characteristic is a curved line, the value of x will be given by the intercept of the second secondary with the top or right scales.

The second secondary is a straight line passing through the left lower origin and parallel to the first secondary.

In conclusion, it is hoped that this presentation of one phase of a subject that is capable of being made a far more useful tool to the busy engineer generally will lead to an extension of its conveniences to cover other general expressions likely to come up in the practice of engineers in various special lines.

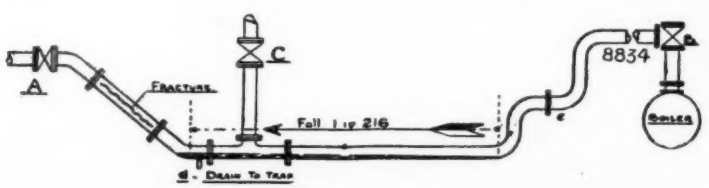
Water-Hammer in Steam Pipes.

EVERY year some lives are lost by the fracture of pipes or valve casings by water-hammer. Last year the loss was heavier than usual. Six men were killed, three of them by one explosion. In nearly all the cases recorded since the passing of the Boiler Explosion Act in 1882, the water-hammer might have been prevented if those who set it in motion—and in many instances suffered from its effects—had understood the probable consequences of their acts. It therefore seems worth while to call special attention to each of the twelve cases recorded in the Abstracts of Board of Trade Reports,* by describing the conditions existing at the time the water-hammer occurred, and the specific act which caused it, in the hope that those who have to design steam mains, or to operate the valves and drains in connection with them, may avoid the pitfalls which these Reports disclose. The sketches used for illustration are not copies of the drawings in the Reports, but merely diagrams showing the particular features of the pipe arrangement which were contributory to the occurrence of the water-hammer.

No. 1,669.—Initial conditions: Pipes 250 ft. long, newly erected and uncovered. Drain d blocked by cement jointing material and rust. Stop valve A to other boiler and boiler junction valve B shut down to re-make joint at e, valve C left open. Water accumulated in pipe before stoppage, cooled during stoppage.

Act which caused fracture.—Opening valve B.

The mistake here was in relying on a steam trap for draining a new pipe. A large drain cock, without a waste pipe, should have been fitted close to the pipe. The arrangement of the pipe was bad: it should have been made as shown, with a well-pipe provided with a small try cock, or some kind of float tell-tale, and a large drain cock, to be subsequently connected



No. 1,669.

* Nos. 1,669, 1,673, 1677, 1,678, 1,683, 1,685, 1,700, 1,717, 1,722, 1,727, 1,737, and 1,738. British Empire Boiler and Electrical Insurance Co., Ltd., Manchester, Chief Engineer's Report for 1907.

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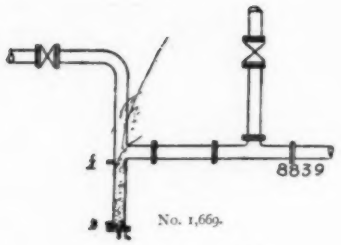

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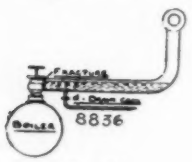

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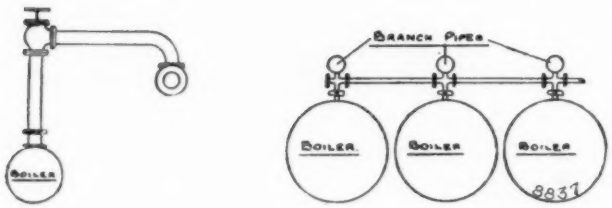

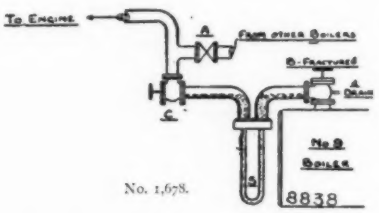

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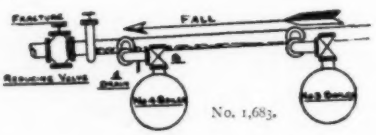
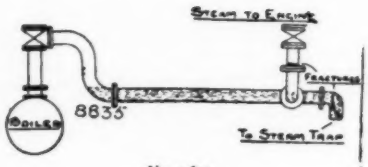


No. 1,683.

to a steam trap. The try cocks, or float, would have enabled the engineer to ascertain if the water were below the horizontal length of pipe before he opened the drain cock or the junction *B*. Try cocks, if used, must be very small, and opened for a very short time, otherwise the discharge from them may be sufficient to disturb the surface of the water in the horizontal length of pipe, and thus start the water-hammer they are intended to prevent. Floats will be referred to later.



No. 1,673.

No. 1,673.—Initial conditions: Steam kept up on Saturday and Sunday, and boiler junction valves left open. Steam trap blocked. Horizontal length of pipe filled with condensed steam.

Act which caused fracture.—Opening valve to engine.

Here again the fault was trusting that the steam trap had kept the steam range clear, and opening the valve to the engine without shutting the junction valve. A well-pipe fitted with a small test cock or a float tell-tale would have enabled the man to see if the pipe were clear.

No. 1,677. — Initial conditions: Boiler off for cleaning, junction valve shut. Drain cock *d* left slightly open, and got blocked. Water accumulated in horizontal branch.

Act which caused the water-hammer.—Man opened drain cock *d* full to blow out obstruction.

The fault was in opening the cock without first shutting the junction valves of all the boilers. Where there is more than one boiler the branch pipes should be fixed as below, or if this be impossible for want of head room, all the branches should be drained by large pipes without cocks or valves, leading into a main pipe across the range of boilers, with a connection controlled by a cock to each boiler, as indicated by the diagram, so that when any boiler is stopped its branch pipe will drain into the other boilers.

No. 1,678. — Initial conditions: No. 9 boiler off for three weeks, junction valve *B* closed, stop valve *C* very leaky, open at time of explosion. Drain *d* open, stop valve *A*, leading to other boilers, shut fifteen hours before explosion. Superheater *S* contained water, and possibly also the 7-in. pipe up to level of drain *d*.

Act which caused water-hammer.—Opening stop valve *A* to give steam to engine.

The fault was in opening the valve *A* before closing the valve *C*. The man ought to have known that unless the valves *B* and *C* were absolutely tight there would probably be water in the superheater. He ought, therefore, to nave shut the valve *C* before opening *A*, and left it closed with the water in the superheater till the fire was lighted in No. 9 boiler to boil it off. The drain *d* should, of course, have been fixed at the lowest possible point of the pipe.

No. 1,683.—Initial conditions: Nos. 1, 2, 3 boilers working, No. 4 boiler empty for thirty-one hours; drain *d* slightly open, sluice valve shut. Water accumulated in lower end of steam main and branch to No. 4 boiler, either through slightly opened drain cock getting blocked or through condensation in pipe exceeding discharge.

Act which caused water-hammer.—Opening sluice valve without shutting the stop valves in the other boilers. If the drain *d* had been cross-connected to the other boilers, as shown on the third sketch belonging to No. 1,677, the steam main might have been kept free from water.

No. 1,685.—Initial conditions: Steam left to condense in 90 ft. of new uncovered pipe, varying from 9 in. to 6 in. diameter, during dinner hour; engine stop valve *A* shut, drain *d* shut.

Act which caused water-hammer.—Opening the engine stop valve *A*. The fault was in opening the engine stop valve before closing the boiler junction valve and opening the drain *d*. With the well-pipe overflowing into the steam main, it would have been dangerous to open the drain *d* without first shutting the boiler junction valves. A try cock, or a float tell-tale, would have shown whether the well-pipe was full

No. 1,700.—Initial conditions: Boiler No. 56 empty, junction valve *B* shut, drain *d* shut. Other boilers in connection with steam main *A* working. Condensed steam accumulated in branch pipe and got cool.

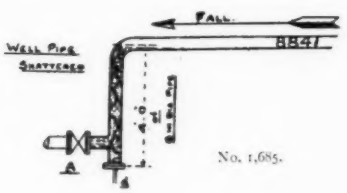
Act which produced water-hammer.—Opening drain *d*.

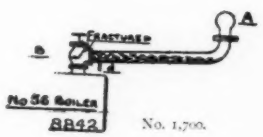
The fault was in opening the drain without shutting off steam from the main *A*. The drain *d* should have been cross-connected to other boilers, or at least to one of them, as shown in the third sketch belonging to 1,677.

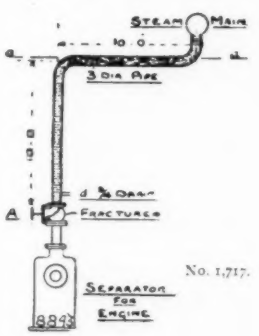
No. 1,717.—Initial conditions: Stop valve *A* shut, drain *d* shut, 3-in. pipe full of condensed steam at low temperature.

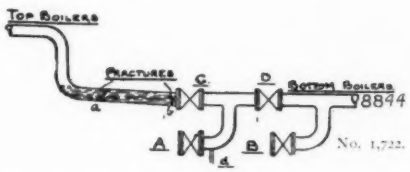
Act which caused water-hammer.—Opening drain *d* two turns, giving an opening of 0·137 sq. in. for two minutes (?), or if this did not lower the water level in the 3-in. pipe to *aa*, opening the stop valve *A* after the drain had been open two minutes (?). Whichever of these acts lowered the water level in the 3-in. pipe to *aa* caused the water-hammer.

The fault was in opening the drain or the valve without shutting the steam off the steam main. The drain should have been trapped







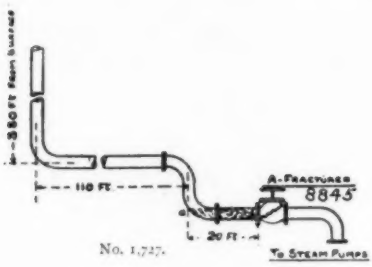


and left open, but the better plan would have been to have placed the stop valve *A* close under the steam main.

No. 1,722.—Initial conditions: Stop valve *C* shut, *D* open. Engine stop valve *A* open, drain *d* shut. Condensed steam had accumulated and cooled in pipe *a b*.

Act which caused water-hammer.—Closing valve *D*, opening drain *a* and valve *C*.

The fault was in opening *C* before closing the junction valves on the top boilers. To avoid the necessity of having to close these valves before opening the valve *C*, the pipe *a b* should have been fitted with a large drain leading to a steam trap, which would have kept the pipe clear so long as the trap acted. But the better



No. 1,727.

plan would have been to have had a pipe-well close to C, drained by a trap, and fitted with a float tell-tale or small test cock, or both, as above described, to enable the man in charge to ascertain whether the pipe were free from water before opening the valve C, and to warn him to shut the junction valve on the top boilers if it were not.

No. 1,727.—Initial conditions: Valve A shut, lower part of pipe filled with water, the result of half an hour's condensation in steam pipe from surface to bottom of pit.

Act which caused water-hammer.—Opening valve A to pumps.

The fault was in opening A before closing the boiler junction valve. A water-hammer was almost unavoidable in this case, because it was impossible to empty the pipe $a\ b$ owing to the seat of the valve A being level with the centre of the pipe. The only chance would be to shut the boiler junction valve, then open A, then open the junction valve a very small fraction of a turn to prevent a vacuum in the pipe, and allow the water to run out through the drain cocks on the pump cylinders down to the level of the seating of the valve A, and then to open the junction valve a little wider, just sufficiently to cause agitation without violent motion of the water remaining in the pipe, in order to heat this water. With great care it might be possible to heat this water sufficiently to prevent water-hammer, but considering the great length of steam pipe this is very doubtful. Had the valve A been a sluice valve, all the water might with care have been got rid of through the drains of the pump cylinders without accident. There should, of course, have been at least a drain at the lowest point of the pipe, which should have been open whenever A was shut, but the proper thing in such a case is a well-pipe with try cocks or a float tell-tale.

No. 1,737.—Initial conditions: Small valve A shut, drains d_5 d shut, drain d_3 d_2 open, boiler junction valve open. Condensed steam accumulated and cooled in end of pipe.

Act which caused water-hammer. — Partly opening small valve A and drain d_5. The water-hammer was not hard enough to knock off the end of the pipe, but it shook the range sufficiently to break it about 200 ft. back.

Again the fault was in attempting to drain off the water without shutting the boiler stop valve. The drain d_5 should have been trapped, or better still, there should have been a well-pipe with tell-tale at the low end of the range.

No. 1,738.—Initial conditions: Engine standing for some hours, valves A, B, C shut, drain d shut. Condensing steam leaking past A and B accumulated and cooled in pipe.

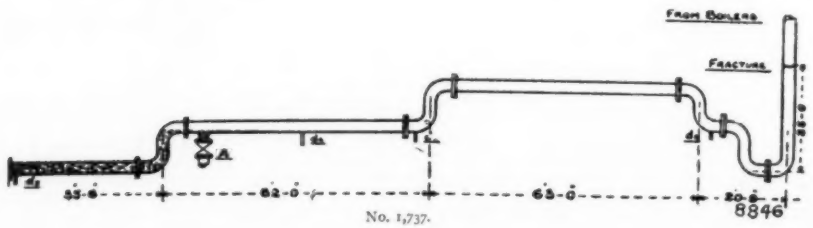
Act which caused water-hammer.—Opening drain d and easing junction valve B.

The first fault was in keeping d shut with leaky stop valves: the second in opening B before all the water had escaped from the pipe.

In all these cases the water-hammer was caused by the disturbance of a comparatively large water surface in a horizontal or inclined pipe, in which the water was capable of moving; and wherever there is such a water surface water-hammer will almost certainly be produced if that surface be disturbed by the opening of a valve or a drain.

Therefore, whenever there is any doubt about the presence of water in such a pipe, it is dangerous to attempt to drain the water away without first shutting steam off from the pipe. From a vertical pipe water can be drained with little risk, because the water resting on the bottom end of the pipe cannot be set in motion.

Mention has been made of a tell-tale for indicating the water level of the water surface in a well-pipe. The writer does not know that there are any on the market, but he is sure that if there were a demand, as there ought to be, something simple and reliable would soon be invented and manufactured. The essential conditions of success are that there must be no



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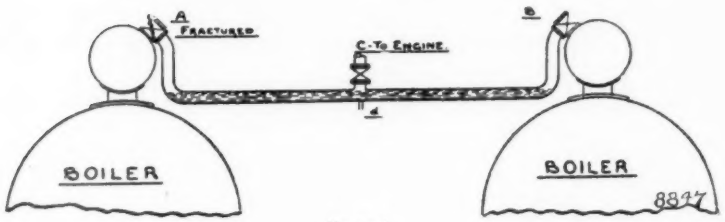
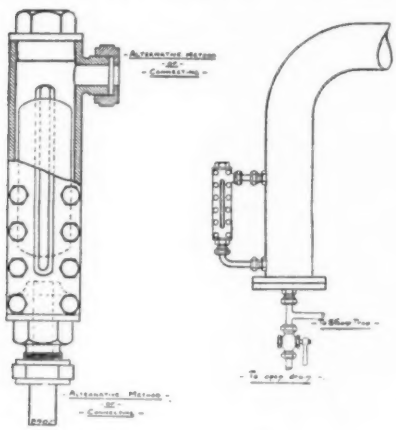


No. 1,738

joint, no hinge, and no gland; that the thing must be cheap and easily applied.

He ventures to make a suggestion which he hopes someone will improve upon. The arrangement is shown in the figs. below. It consists of



a brass box containing a brass or copper cylindrical float, capable of withstanding an external pressure of 250 lbs. per sq. in., which rests upon the bottom when the box is full, and rises to the top when floated by water. Two windows, like those of a "Klinger" water gauge, diametrically opposite to each other, enables a man holding a light behind the gauge to see whether the float is at the top or bottom of the box, even if the glass windows carry a fair amount of dirt, and warn him, if he sees the float at the top or if he cannot see it at all for dirt, to shut the boiler junction valves before attempting to drain the pipe. The float in the first fig. is shown 2 in. diameter and 6 in. long. Probably a smaller float can be made to withstand the pressure and weigh less than the water it displaces. The smallest practicable size, however, can only be ascertained by experiment. The gauge is shown without cocks, because cocks would enable a man to render it inoperative, and it is desirable that any apparatus of this kind should be as far as possible fool-proof. A more convenient arrangement would be to use the float to short-circuit two insulated plugs screwed into the upper part of the box to ring an electric bell, but it has the disadvantage of becoming inoperative if the battery be allowed to run down.

The Adaptability of the Shaper Increased.

By JAMES MUNGALL.

THE contrivance which forms the basis of this article is a piece of smart workshop practice, adding, as it does, an entirely new motion to a standard machine tool, and thus considerably increasing its utility. The operation which the apparatus was primarily designed to accommodate, was the cutting of a true helix (or screw) upon the faces of two half-clutches, in order to ensure their being in dead contact at every point when fitted together in working order. Further, the apparatus was to be capable of repeating the operation upon any subsequent replace clutches with complete accuracy.

The photograph Fig. 7 clearly shows the difficult nature of the job. The upper surface had to be a true helix from point to point, with a keen corner at the bottom of the thread. Here the real difficulty arose as, had there been a safe margin at the bottom corner, the operation would have been a simple, though perhaps tedious, one for the lathe.

The lathe proving insufficient for the purpose, the universal milling machine was next tried, but the same trouble was encountered as in the case of the previous machine, a fine corner not being obtainable even with an end milling cutter, on account of the angle of the screw. The shaper was finally decided upon and the apparatus described below designed.

The clutch is first cast in steel roughly to shape, a good allowance being left for machining the face. The lower parts are turned and finished to size, the shaping of the screw being the last operation. In order to ensure a correct lead of the screw, it is essential that the shaper table shall provide a rising or falling, and at the same time a revolving, motion to the clutch. This combination of motions cannot, of course, be obtained with the ordinary table and gearing, and it is necessary to alter the design of the machine to the extent of replacing the table with one of special design.

Fig. 1 shows a table which fulfils the requirements of the new operation and, at the same time, is capable of dealing with the ordinary work of the machine. This obviates the necessity of changing the table each time the machine is required for every-day work.

The upper portion of the table is provided to take up the thrust of the cutting tool only, the clutch being carried upon gearing fitted to the lower table. The table is secured to the machine cross-slide by bolts, three on the top and three in the front, as shown in the sketch. The table must be of rigid construction to withstand the leverage of the cutting tool, and at the same time its weight must be taken into consideration as, owing to the vertical motion, there is no means of supporting the front of the table by a leg as is ordinarily done. The principal dimensions of the one in use are: upper portion, $2\frac{1}{4}$ in. thick; lower portion, $3\frac{7}{8}$ in. thick, cored as shown; ribs, 1 in. thick; bolts, $\frac{3}{4}$ in. diameter; material, cast iron. These sizes give sufficient rigidity to prevent excessive vibration with a cut of $\frac{3}{16}$ in. deep by $\frac{1}{32}$ in. feed.

The bore of the upper table is to allow the pinion end of the clutch (which is larger than the body) to pass through, and, with the addition of the recess shown, it serves as a bed for the thrust collar. Several of these collars are necessary, the outside diameters being the same, but with different bores to suit various sizes of clutch bodies. The collar (shown in Fig. 2) is in two

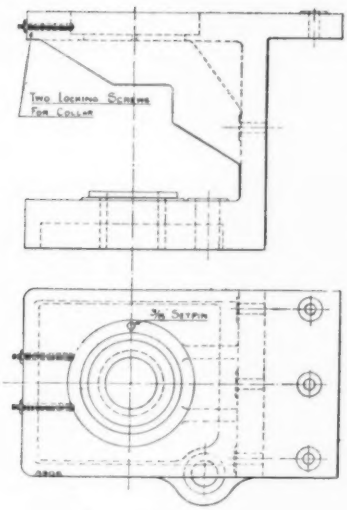


FIG. 1.

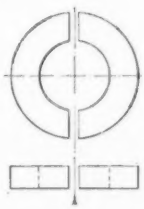


FIG. 2.

segments, and is placed in position after the clutch pinion is passed through the table, but before it is fastened down to the gearing below. To prevent the collar revolving when the clutch is in motion, a setpin, screwed into the table recess, divides the two segments and provides an efficient stop. To take up any wear which may occur, and to keep the collar in close contact with the job, two setscrews are fitted as shown in Fig. 1. Each is supplied with a locknut, the screws having square spanner ends to allow these nuts to be screwed up after adjustment.

The requisite gearing for supplying a circular motion to the clutch necessitates modifications and additions to the existing ratchet feed. In the ordinary course the ratchet feed is coupled up to the cross-traverse motion shaft, while the vertical feed of the table is operated by hand. Under the new conditions the reverse of this is essential. The change is easily accomplished as follows: the pinion wheel *A* (Fig. 3) (with its attachment of guard and guide rod) is slewed round from its original position to that shown, and the ratchet rod and gear detached from the cross-traverse shaft and coupled to the lower shaft for operating the vertical motion of the table. It is necessary to supply a new ratchet wheel *J*, calculated to give a correct ratio of rise of table to revolution of clutch. The sleeves and minor details, however, can all be transferred to their new position without any alteration.

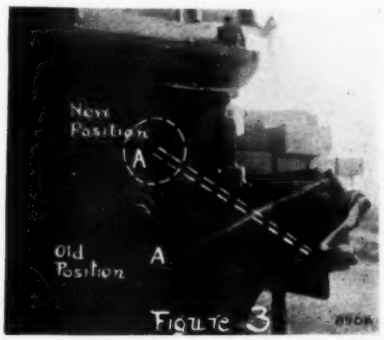


FIG. 3.

The above is the only deviation from the standard machine necessary to obtain the requisite vertical travel of the table. For the revolving motion a train of new gearing is required. The ratchet is again utilised, not only because it is the most convenient form of transmission, but also to give a certain amount of variation in the rate of revolution. An additional pinion wheel *B* (Fig. 4) is fitted in the old position of the original pinion *A*, and driven by the same hub wheel. A cast iron bracket for carrying the pinion *B* is shown at *C* in Fig. 4. This is fixed to the side of the machine with setscrews. The method of securing the pinion to the bracket is apparent from the illustration and requires no explanation.

A ratchet rod *D* (Fig. 4) is supplied, bent as shown to clear the bed of the machine. The adjustment groove, lock,

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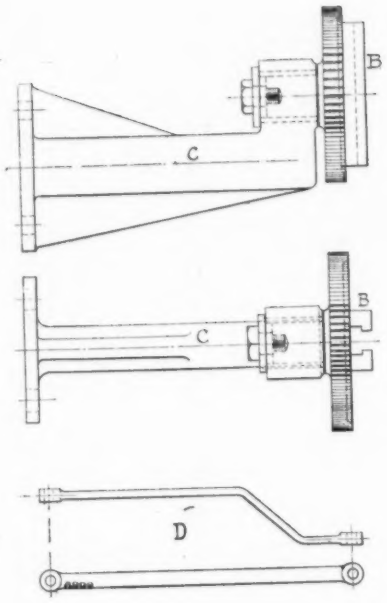

FIG. 4.

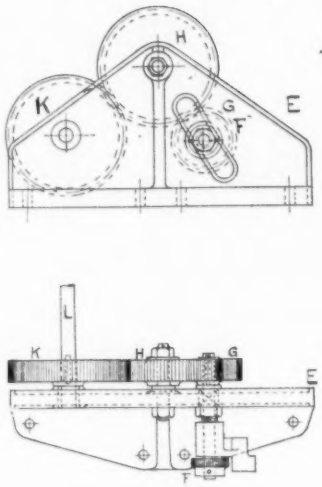

FIG. 5.

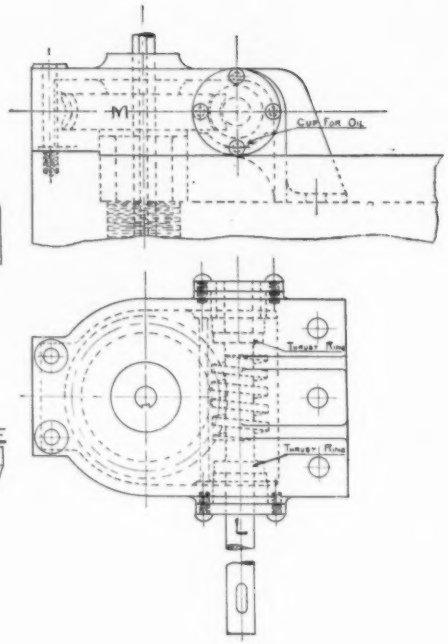

FIG. 6.

pins, pawl, &c., are similar to those used on the standard ratchet gear. The reciprocating motion of the ratchet rod is converted into a circular motion by the train of gears shown in Fig. 5. This gearing is carried by a cast iron bracket *E*, which is bolted down to the concrete floor alongside the machine. The slot in the bracket is of a radius equal to the length of the ratchet rod, and is to admit of alteration in the size of gear used. This is necessary to obtain a variation in the speed of revolution for different leads of clutches.

The ratchet pawl engages with the wheel *F*, which is secured to the spindle by means of a key driven tightly home. The pinion *G* is fitted over a sliding key and secured by a washer and split pin. This allows the wheel to be

changed with the minimum amount of labour. *H* is an idle wheel, transmitting the motion from *G* to *K*, and remains a fixed quantity. It runs loose on a spindle bolted to the bracket and secured by a nut and split pin, as shown in Fig. 5. The pinion *K* is attached to the shaft *L* by means of a feather, the shaft itself running loose in a brass bush in the bracket at one end, and into the worm box at the other. It will be seen from the following description of

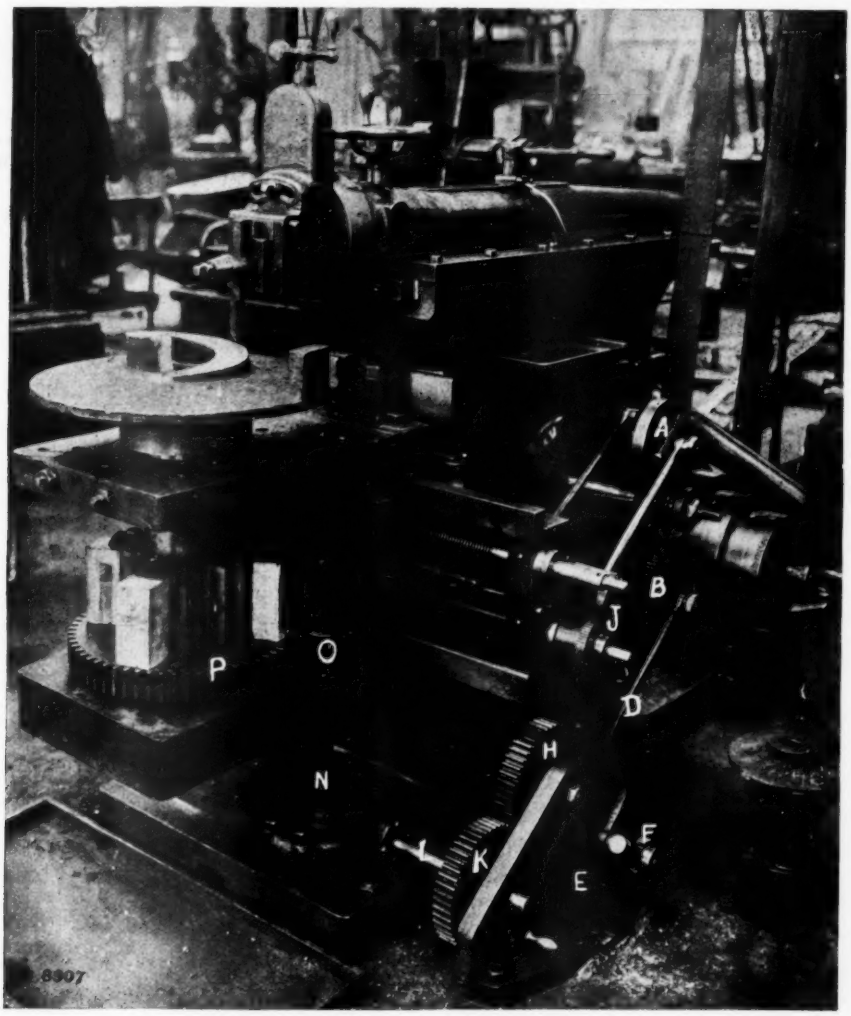

FIG. 7

the worm gear that this shaft does not require to be secured to the bracket, its limits of end movement being fixed in the worm box.

This worm box is shown in detail in Fig. 6. The casing is of cast iron, bolted down to the machine bed by five bolts. It is of rigid construction and ribbed externally to take both transverse and vertical thrusts. An oil bath is provided by the cup cast on the inside of the worm box and running the full length of the thread. The well is of sufficient depth to allow of good lubrication to the whole of the frictional surface of the worm, the oil being replenished by an oil-hole in the worm box top. The worm itself is part of the shaft *L*, the thread, together with the thrust rings at each end, being cut out of the solid. The collars take up the thrust of the worm and limit the play of the spindle. A brass washer is placed between the thrust collars and the cast iron gland. These glands, which are to enable the worm to be easily withdrawn, are secured to the worm box by four screws, and are fitted with brass bushes.

The worm wheel *M* drives the shaft *N* running vertically up to the table. In order to allow the shaft freedom to follow the table in its vertical feed, a sliding key is used as a connection between the wheel and the shaft. For the same reason also, a hole is bored through the bed of the machine and into the concrete floor to accommodate the bottom end of the shaft when in its lowest position.

The upper end of the shaft passes through the lower table, and on it is securely keyed the pinion *O* (Fig. 7), gearing into and driving the spur *P*. This spur has an extension piece cast on the underside, machined a running fit for the brass bush in the web of the table and screwed at the end to take two nuts. The nuts are tightened sufficiently to prevent any play, but not enough to restrict the easy revolving of the wheel. The bush is provided with a shoulder to take any wear due to the weight of the clutch.

The spur *P* is in reality a subsidiary table carrying the clutch, and for this reason is provided with slots to take tee-headed bolts, the slots running radially from the centre outwards. No setting of the clutch is necessary, as it is centralised by the split collars in the upper table.

The reader who has followed the foregoing description closely, will have a clear conception of the mechanism and the manner in which the combination of movements is obtained. A very distinct illustration of the apparatus in working order is shown by the photograph in Fig. 7. The different details are symbolised to facilitate reference to the sketches and description.

This article would be somewhat incomplete without some reference to the calculations used to obtain the correct ratios. An example is given below:

Basis: A cutting feed of $\frac{1}{32}$ in. It is not advisable to give a coarser feed or a series of steps may result. Clutch: Lead of screw required = 2·631 in. = rise of table in one revolution of clutch. The table is fixed to travel $\frac{1}{4}$ in. in one turn of the vertical motion shaft. The number of teeth upon the ratchet wheel for this shaft is 76, and the vertical motion ratchet gear being adjusted to take one tooth per stroke, this gives a total number of strokes for the lead required of 800. It is therefore necessary to accomplish the complete revolution of the clutch in 800 strokes of the machine, and this is given by the following sets of gears:

Ratchet wheel *F*	..	32 teeth.
Pinion *G*	..	24 ,,
Idle wheel *H*	..	48 ,,
Wheel *K*	..	48 ,,
Worm	..	Single thread.
Worm wheel	..	25 teeth.
Pinion *O*	..	15 ,,
Spur *P*	..	60 ,,

The movement of the two extremes of this gearing, viz: pinion *G* and spur *P*, is in the proportion of 200 : 1. By giving the bottom ratchet a feed of eight teeth per stroke, the revolution is completed in exactly the number of strokes given.

The machine is equipped with a set of four change wheels, and it is interesting to note the very considerable number of variations in lead it is possible to cut with this small number. The total

number of leads given by changes of gear is 52, varying from 1 in. to 6 in.

In conclusion, it may be stated that the apparatus has now been in constant use for a considerable time, and has worked throughout without any trouble. The operation is purely mechanical and requires little attention. The resulting clutches are not only a good close fit one to the other, but replace halves can be supplied and fitted without any dressing by hand whatever.

Report of the British Association Committee on Gaseous Explosions.

(*Continued from page 292.*)

Thermal Equilibrium.—When an explosive mixture of gases is ignited in a closed vessel the effect of the change of pressure during the progress of the flame from the point or points of ignition is to raise the temperature round about those points much above the mean temperature, and, on the other hand, the temperature attained at those places which are last reached by the flame, and where the gas is compressed before instead of after ignition, is much below the mean. Even in a vessel whose walls are impervious to heat the difference of temperature between the points first and last inflamed might amount to 700° C. at the moment of maximum pressure.* In a real explosion the cooling effect of the walls causes the temperature to range from perhaps 300° or more above the mean (as shown by the pressure) right down to the wall temperature at points close to the metal. The existence of large temperature differences in the gas close to the walls of an engine cylinder was first experimentally demonstrated by Professor Burstall with the aid of platinum thermometers.

If the volumetric heat of the gas were constant the equalisation of these temperature differences by convection and conduction, could it take place without loss of heat, would cause no change of pressure. The volumetric heat is, however, not constant, but may quite possibly be 50 per cent. greater in the hottest than in the coldest part of the mass. The attainment of thermal equilibrium must, in fact, cause a change of pressure, and would contribute to the correction which has been designated p (see Fig. 3). The amount of the change might be the subject of rough calculation, taking an assumed distribution of temperature and assuming values for the volumetric heat. Such a calculation in the present state of knowledge would only be of value as showing the possible order of magnitude of the quantity sought, and the assumptions made could therefore be of a character to make the calculation fairly simple. More accurate knowledge both of temperature distribution and of thermal capacity will enable greater accuracy to be attained in the estimation of this correction, which will be of such a kind that a method of successive approximation can be pursued, the revised values of thermal capacity resulting from its application being applied to a more accurate calculation of the correction if necessary.

The temperature variation set up by the cooling action of the walls is a surface phenomenon, and as such the correction which it necessitates can probably be determined and eliminated by experiments with vessels of different sizes. The variation caused by the change of pressure during the period of inflammation is not of this character; and the necessity for a large correction on this account is quite consistent with the observations of Berthelot, or of Mallard and Le Chatelier and of Langen. In these experiments the maximum pressure reached in the explosion was measured, and at the time of maximum pressure very large differences of temperature are known to exist at a distance from and quite independent of the walls.

Soon after maximum pressure, however, the temperatures at points remote from the walls are equalised to a large extent by convection currents. There then remains only the layer of gas near the walls to be considered in this connection. If, therefore, the measurements be postponed until a long enough time has elapsed to admit of this internal equalisation, the correction becomes of the surface kind, and can be dealt with by the method appropriate to corrections of that type. But in that case the heat lost will be too large a quantity to admit of rough estimation; it must be directly measured.

Chemical Equilibrium.—The view that chemical equilibrium is not attained until some time after the moment of maximum pressure was first put forward by Clerk in 1885, who then expressed the opinion that the greater part of

* *Proc. Roy. Soc.*, A, vol. lxxvii. p. 389.

the so-called "suppression of heat" in explosions was to be ascribed to this cause. On the other hand, Continental writers have almost completely ignored it For example, Langen makes practically no reference to this in his paper. It can hardly be doubted, however, that in many explosions, especially of weak mixtures, a considerable amount of the energy is in the chemical form at the moment of maximum pressure. On the other hand it seems probable to the committee that the amount of unburnt gas at this moment in such experiments as those of Langen was not such as to very greatly affect the results. This belief is based on the supposition that the incomplete combustion is due to the cooling action of the walls. It seems probable that very shortly after the attainment of maximum pressure, that is, within a time small compared with that required to reach maximum pressure, the transformation of the chemical energy into thermal form is everywhere complete except in a thin surface layer where this transformation is retarded by the cooling action of the walls.

If this view be accepted, the correction of the results for incomplete combustion is of the nature of a surface correction, and can be determined by comparing the pressures reached by the same mixture when exploded in vessels of different sizes.

In the discussion of this important matter the committee have derived great assistance from the experience of Professors Dixon and Bone, who have made a special study of the velocity of chemical action in gases. These gentlemen are of opinion that though such action may be of great complexity, involving in many cases several successive molecular operations, yet, if it is not retarded by the presence of cold foreign bodies, it will generally be completed within a period which, for the purposes of gas-engine theory, may be regarded as negligibly small. In the simple case of the explosion of hydrogen and oxygen they consider that the complete transformation of the mixed gases into steam at any given point is complete within a time measured by the interval between molecular collisions. When the action is more complicated, as in the explosion of carbon monoxide and oxygen in the presence of water, or in the combustion of hydrocarbons, the period will be larger, but will still be measured by thousandths of a second.

Some direct evidence that incomplete combustion in an explosion is mainly, if not entirely, a surface phenomenon is to be found in Hopkinson's measurements of the temperature at points within a large explosion vessel by means of a platinum thermometer. A photographic record of the resistance of a fine platinum wire immersed in the gas showed that when the flame reached it the temperature rose in less than $\frac{1}{40}$th of a second from 20° C., which was the temperature of the unburnt gas, to about 12,50° C., which was that of the burnt gas, and that it remained at the latter figure quite steadily except in so far as the increase of pressure in the vessel caused it to rise. In other words, there was no increase of thermal energy except that due to work done upon the gas from outside.* The mixture was one part of coal gas to nine parts of air—a slow burning mixture—and the time taken to reach maximum pressure was about a quarter of a second, or at least ten times that required for combination of the gases at any one point. It is true that the vessel was of rather larger size—about six cubic feet capacity, but, on the other hand, owing to the fact that the platinum wire extended over about 1 cm., so that the flame took an appreciable time to completely envelop it, it is probable that the period of $\frac{1}{40}$th of a second, given above, is a superior limit which greatly exceeds the actual time taken to effect the combination at any one point.

On the other hand, it cannot be doubted that combustion must be greatly retarded in the neighbourhood of the cold metal walls; and there is nothing to show that this surface retardation is not sufficient to account for all the phenomena of delayed combustion. A simple calculation based upon the rate of flow of heat per square foot into the metal of a gas-engine cylinder (which is roughly known from measurements of the heat carried away by the jacket water) shows that the mean temperature of the exposed surface at points separated by an inch from the cooling water cannot exceed quite a moderate value. Probably about 200° C. is a superior limit for the cylinder liner. Similar calculation of a still rougher kind, but still sufficiently accurate to give the order of magnitude of the quantity sought, shows that the fluctuation above and below the mean in the course of a cycle is very unlikely to exceed 20° C. The latter conclusion has been confirmed by some experiments made by Professor Coker, with a preliminary account of which he has favoured the Committee. Measuring the cyclical variation of temperature of the inner surface of a 12-h.p. gas-engine cylinder by methods similar to those adopted by Professors Callendar and Nicholson in their well-known work on the steam engine, he found that the maximum was only 7° F. in excess of the mean. The direct measurements by Professor Hopkinson of the temperature of the walls of an explosion vessel lined with copper strip also lead to the conclusion that it is quite moderate. This cold metal must obviously profoundly affect the combustion in its neighbourhood. In a layer of gas of appreciable thickness the combustion will be of a smouldering character, depending upon the velocity with which the unburnt gas in contact with the walls can diffuse into the hotter regions at a distance from them, and so be brought to the ignition temperature. This layer, being cold and highly compressed, might account for a considerable fraction of the heat, though its actual thickness may be only a few tenths of a millimetre. It would appear probable that the

* *Proc. Roy. Soc.*, A, vol. lxxvii. p. 387.

continued burning which undoubtedly goes on after the time of maximum pressure in many explosions, and probably also occurs during the first portion at least of the expansion stroke of a gas engine, is mainly of this character.*

Motion of the Gas.—In many explosions intense vibratory motions of the gas are set up. The effect of these sometimes appears with a quick-period indicator as a rapid variation of pressure. It is a question of some importance how these motions affect the *mean* pressure shown by a gauge. The damping-down of the motion which occurs in consequence of viscosity of course only means that the motion becomes distributed among the molecules in a random way, instead of following a definite arrangement. The total kinetic energy remains the same. But it is not certain that the mean effect on a pressure gauge of the molecular impacts will be the same. This is a question which might be considered by someone to whom the methods of the kinetic theory of gases are familiar. It is, of course, not a surface phenomenon.

Results of Observations.—The temperatures reached in these explosion experiments range from about 1,300° C. up to 3,000° C. Temperatures of below 1,500° C. are, however, obtained by the use of weak mixtures, involving slow burning and large cooling corrections, and but little reliance can be placed on the results. Langen made a very few observations on mixtures giving a lower temperature than 1,500° C., and takes that as the lower limit of the range of temperature to which his observations apply. The extreme upper limit of the constant pressure experiments is 1,400° C. The temperature of 3,000° C. is about that reached in the explosion of hydrogen and oxygen in their combining proportions. This is much above the mean temperature ordinarily reached in the gas engine, the upper limit of which may be put at about 2,000° C.; though it is probable that 2,500° or more is occasionally reached locally. Langen, however, places the upper limit of the application of his formulæ at 1,700° C., on the ground that there is dissociation of the CO_2 at higher temperatures than that. There does not seem to be much reason for this limitation, for the effects of dissociation (provided that equilibrium is attained) are indistinguishable from those of increasing specific heat, and should be included in the change of energy. Dissociation may give rise to errors in the temperature measurement, but there is reason to suppose that the dissociation which occurs in the CO_2 in steam at a temperature of 2,000° C. is too small to cause any material change of volume, though it may mean considerable absorption of heat.

* Professor Bone is doubtful whether "smouldering combustion" plays so considerable a part in gaseous explosions as is here suggested.

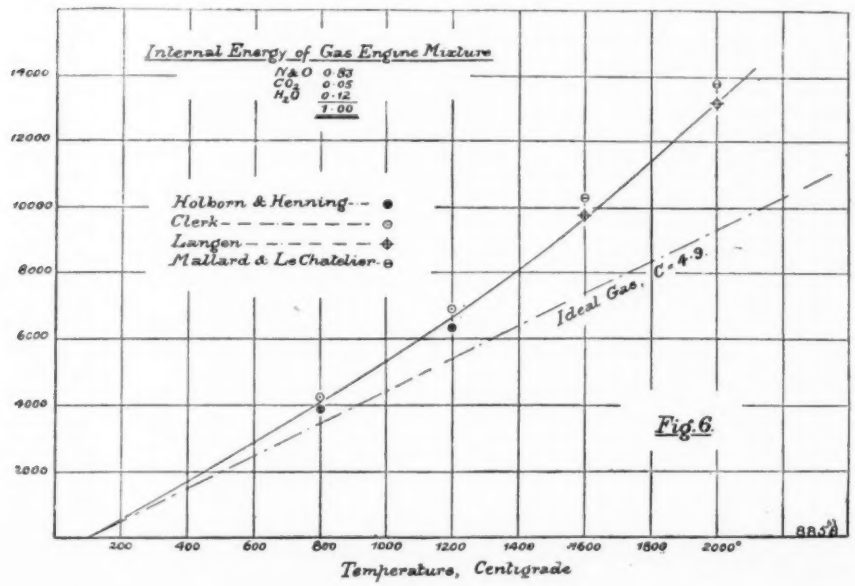

Fig. 6.

The formulæ given by Langen as representing the results of his observations, are as follows :

$$\text{Air } \bar{C} = 4{\cdot}8 + 0{\cdot}0006\,t.$$
$$CO_2\ \bar{C} = 6{\cdot}7 + 0{\cdot}00260\,t.$$
$$H_2O\ \bar{C} = 5{\cdot}9 + 0{\cdot}00215\,t.$$

where $\bar{C}$ is the mean thermal capacity over the range o to $t°$ C. The explosion pressures predicted by the use of the formulæ agree well with the observed pressures, except in the case of mixtures of CO and air, where they are a good deal too high. In other cases the maximum deviation is about 4 per cent.

Mallard and Le Chatelier represent their results by formulæ, which differ greatly from the above in the case of CO_2 and H_2O, though the formula for air is the same. This discrepancy must be due in some way to the method of reduction adopted, for, as already pointed out, the explosion pressures reached with mixtures of the same composition are very nearly the same.

Taking Langen's values, the following table exhibits the energy of the various simple gases, and of the mixture on which Clerk experimented, at 1,600° and 2,000° respectively. The energy of the same gases at 800° C. and 1,200° C. based on Holborn and Henning's and Clerk's results is also given for comparison. The results are given in calories per gramme molecule. To reduce to ft. lbs. per cu. ft. multiply by the factor 3·96.

—	800°		1200°		1600°	2000°
	Clerk.	Holborn and Henning.	Clerk.	Holborn and Henning.	Langen.	Langen.
Air ...	—	3,570	—	3,840	8,700	11,500
CO_2 ...	—	6,460	—	10,880	17,000	23,300
H_2P ...	—	4,670	—	7,930	14,400	19,900
Gas engine mixture	4,250	3,840	6,900	6,340	9,800	13,200
Ideal gas*	3,430	—	5,400	—	7,350	9,300

* C = 4·9.

The results for the gas engine mixture are plotted on Fig. 6, on which points obtained by Mallard and Le Chatelier's formulæ are also shown.

The energy of gas engine mixture at 1,400° C. according to Clerk, Holborn and Henning, and Langen respectively would be as follows :—

Clerk	8,300
Holborn and Henning	7,700
Langen	8,300

It will be seen that the agreement between Clerk and Langen is close, both being about 8 per cent. higher than Holborn and Henning. But it is to observed that this temperature is just outside the range of all three sets of experiments.

The Commitee are of opinion that values ot the energy obtained from explosion records are not subject to any very great errors on account of heat-loss by conduction to the walls of the vessel, nor on account of incomplete combustion, but that they are affected by errors of quite unknown amount due, first, to heat radiated, and secondly, to the want of thermal equilibrium at the time when the pressure is measured. For the purpose of testing the first of the conclusions it is very desirable that further experiments should be made on explosions in vessels of greatly different size but of similar form. The opinion entertained by the Committee that incomplete combustion is a surface phenomenon, on which this conclusion as to the validity of the method is based, also requires further confirmation. As regards the second conclusion, further experiment on the actual amount of heat radiated by burning gas is urgently required, and also experiments to confirm or negative the effect of the nature of the wall surface upon the pressure reached in an explosion. The effect of want of thermal equilibrium can be determined up to a point by calculation ; but before such calculation can be usefully made, it is desirable that further information should be obtained as to the temperature distribution after an explosion, especially in the neighbourhood of the walls. It should not be difficult to get an idea of this sufficiently accurate for the purpose by means of platinum thermometers.

The most hopeful way, however, of making use of explosions to give definite information as to the properties of gases, would appear to be to directly measure the heat lost in the explosion, as if this be done it is possible to defer the pressure measurement until such time as equilibrium conditions, except those that depend on the surface of the vessel, have been attained.

THE MEASUREMENT OF TEMPERATURE.

In all the experiments for the determination of the energy function which have been described above the measurement of the temperature is ultimately based upon the pressure or volume changes of the gas. In the constant-pressure experiments of Holborn and Henning the temperature of the gas before entering the calorimeter was by means of a thermo-couple which had been compared with a constant-volume nitrogen thermometer up to 1,600° C. In the explosion experiments the mean temperature of a gas is inferred from its pressure. Similarly, in the analysis of the gas engine diagrams, the gas is itself the thermometer. The mean temperature at any point is taken as proportional to the product pv, and the actual temperature at one point in the cycle (a knowledge of which is necessary for getting absolute values) is obtained either by estimating the quantity of gas present in the cylinder or by direct measurement with the platinum thermometer, as was recently done by Callendar and Dalby.

The temperature scale so obtained is probably sufficiently definite, at any rate for the purpose of gas-engine theory, since the mixture to which

it is applied does not vary very greatly in composition, and always consists mainly of nitrogen. It is not so certain, however, that this scale agrees with the absolute thermodynamic scale; and the question of the possible amount of the deviations at temperatures of 1,500° and over is of great importance in connection with the present inquiry.

So far as the Committee are aware, the experiments of Joule and Thomson still remain the only comparison between the various gas-scales and the thermodynamic scale; this comparison only extended to about 200° C., and is, of course, of no application to the problem now under discussion, except in so far as it gives an idea of the differences to be expected at higher temperatures. What it really shows is that thermometers constructed of the more permanent gases are all so closely accordant with the thermodynamic thermometer as to lead to the belief (as a matter of induction, and quite independently of the kinetic or any other theory) that there is really some definite cause tending to make a gas, as such and apart from its composition, obey the law $\frac{pv}{\theta}$ = constant. It would appear that the small deviations from this law, sometimes one way and sometimes the other, which are observed must be due to disturbing causes depending on the nature of the gas, whose influence may be in either direction and is of very various amount, but is at low temperatures small compared with the tendency to obey the perfect gas law. This view being accepted, there is a strong presumption that, if a number of thermometers constructed of different gases be compared at high temperatures and be found to agree fairly well, then they all agree with the thermodynamic scale at least as well as they agree with one another. It is upon the agreement between different gas thermometers that our belief in the measurement of temperature is really founded, and, so far as it goes, the foundation seems to be sound.

The nitrogen thermometer has been used with an iridium bulb up to 1,600° C.,* but no other gas has been taken above 1,100° C. At the latter temperature the differences between thermometers constructed of hydrogen, nitrogen, and air are quite negligible for the present purpose. Rather more deviation has been observed in CO_2; but having regard to the small percentage of this gas which is ordinarily present in the gas engine mixture, it is not likely that temperatures up to 1,100° C., calculated in the usual way from the indicator diagram, will differ much from the true temperatures on the thermodynamic scale. 1,100° C. is, however, not much above the lower limit of the gas-engine range; as to what goes on in the upper part of that range we have little or no evidence.

When considerable deviation from the gas laws at high temperatures is observed in the case of any gas, it is usually ascribed to dissociation. For example, if comparison be made of two constant-pressure thermometers filled respectively with hydrogen and with iodine vapour, they will be found to agree up to about 1,000° Abs.; the iodine thermometer will then begin to read higher than the hydrogen thermometer until, when the latter reads about 1,800° Abs., the former will read about double that amount. When the gases are hotter still the temperature shown on the iodine thermometer will continue to be double that shown on the other. In this case the departure between the two thermometers is accompanied by a change in the absorption spectrum of the iodine vapour; and the whole phenomenon is expressed by saying that the iodine molecule has been split up or dissociated. In the case of a compound gas this dissociation sometimes takes the form of an actual separation of the constituents, which can be detected by diffusion. A great deal of experimental work has been done with the object of ascertaining to what extent the gases CO_2 and steam split up at high temperatures. These gases are constituents in most gas engine mixtures, and if they dissociate to any considerable extent there will be a corresponding effect upon the $pv\theta$ relations of the mixture of which they form a part. So far, however, there is, in the opinion of the Committee, no conclusive evidence that either steam or CO_2 is dissociated to an extent which is material for the present purpose. Slight traces of dissociation have undoubtedly been found in both cases, but the method of experiment is such as to leave it doubtful how far these have been conditioned by the nature of the walls through which the dissociated gas is diffused. It must be observed, moreover, that CO_2 and steam usually form only a small part of the mixture in the gas engine, and that therefore a considerable amount of dissociation of these gases would be necessary to produce much effect upon the pressure of the whole. Again, such dissociation, if it occurs, must have an effect upon the energy of the gas out of all proportion to the effect which it has upon its temperature. Take, for example, the case of a mixture formed by the explosion of CO and air and containing 10 per cent. of CO_2, the remainder being nitrogen. If, by heating, one tenth part of the CO_2 be split up into CO and oxygen, the resulting change of pressure of the whole mixture will be only one two-hundredth part; but this amount of dissociation could only be effected by the absorption of an amount of heat of the order of 10 per cent. of the total heat of combustion of the gas. In other words, the mean specific heat of the mixture, as determined by the explosion, would be roughly 10 per cent. lower than if there had been no dissociation. Any considerable departure from the gas laws in such a mixture, if it be ascribed to dissociation at all, must therefore be put down to dissociation of the nitrogen, which might conceivably occur at 2,000° C., just as iodine vapour is dissociated at a much

* Holborn and Valentiner, *Ann. d. Phys.* xxii. (1907), p. 1.

lower temperature. It does not seem likely, however, that if nitrogen dissociates its splitting-up would be accompanied by any visible change in its physical properties, such as is observed in the case of iodine. The phenomenon in this case would be rendered evident only by the departure from the gas law, and possibly by absorption of heat.

It would appear, therefore, that our knowledge of thermometry at these temperatures is more likely to be advanced by direct experiments on the relation between the pressure or volume and the temperature than by looking for other evidences of dissociation. The difficulty in carrying the comparison of different gas thermometers to very high temperatures has hitherto lain in the absence of any material sufficiently refractory to withstand such temperatures, and at the same time sufficiently impervious to the gas. Dr. Harker, to whom the Committee are greatly indebted for much information upon this subject, believes, however, that he is now in possession of a material which will satisfy both of these conditions up to a temperature of 1,800° C., and he has suggested that an attempt should be made to compare thermometers constructed with nitrogen, with CO_2, and with argon up to that temperature. If the nitrogen and argon thermometers are found to agree, then, by reason of the great difference in the constitution of these gases, it is almost certain, as explained above, that each agrees with the thermodynamic scale. If, on the other hand, they do not agree, then the presumption is in favour of the argon thermometer, because this gas is supposed to be monatomic and to be incapable of dissociation. The Committee venture to express a hope that a research on these lines will be commenced and carried to a conclusion. They believe that the results obtained will be of very great importance in the investigation of explosions and in the theory of the gas engine, and it seems to them an inquiry eminently fitted for the National Physical Laboratory.

The comparison of gas thermometers is, however, not the only way in which the problem of thermometry at high temperatures may be attacked. Another method, and one that is more satisfactory in some ways because it is more fundamental, is to investigate the dependence of the energy upon the density of the gas. As pointed out at the commencement of this Report, any interdependence between energy and density at a given temperature must be accompanied by a corresponding deviation from the perfect gas law, and investigation of change of energy with density must be the ultimate basis of gas thermometry. The Joule-Thomson experiment was, of course, of this character. Since then Joly has determined the change of specific heat of CO_2 at pressures ranging up to the critical pressure. But these determinations refer only to temperatures of the order of 100° C. As was pointed out at the commencement of the section of this Report dealing with explosions, the corresponding measurement at very high temperatures can be very easily made when once the various corrections necessary to determine internal energy by explosion experiments have been satisfactorily performed. It is only necessary to compare the pressures reached in explosions of mixtures identical in composition but of different density. Should the pressures after explosion, when corrected, be proportional to the pressures before explosion, then the energy is independent of the density, and we have proof that the gas law holds up to the temperature reached by the combustion. On the other hand, a departure from the proportionality would imply a corresponding departure from the gas laws, the amount of which could be calculated. Mallard, Le Chatelier, and Langen have made very careful comparisons of this kind, and they have found that the actual maximum pressures reached in the explosions are in many cases very approximately proportional to the pressures before explosion. Petavel has found that this proportionality is not much altered even when the density of the gas is increased seventy times. This may be regarded to some extent as evidence that there is no very great difference between the gas scale and the thermodynamic scale at the temperatures of 1,700°, or more, which were reached in these experiments. But it must be observed that this inference is subject to the same limitations as the determinations of internal energy based upon these experiments. It cannot be regarded as having a secure foundation until the various doubtful questions in regard to heat loss and delayed combustion, which have been raised above in this connection, have been satisfactorily determined.

XUM

GENERAL REVIEW

Leading Articles of the Month—Current Events—Technical Information from all Sources.

The "Wright" Aëroplane.*—Generally speaking, the "Wright" aëroplane may be described as in the main two parallel plane surfaces mounted one above the other, and provided on the front with a rudder horizontally disposed, and this, too, is made of two surfaces. In the rear of the machine, to the left in Fig. 1, is also a vertical rudder, also made up of two parallel plane surfaces. These two fore-and-aft rudders are pivoted along their planes at points so that they are almost balanced, and therefore can easily be swung by the two control levers at the command of the operator. The machine is provided with two propellers, located symmetrically, one on each side of the centre line of the machine and just behind the rear edges of the two large main aëroplane surfaces. An important point is that these two propellers are so geared to the engine (see Figs. 2 and 3) that they run in opposite directions.

The method of connection from the motor shaft to the propellers is direct by chain drive; metal piping surrounds the chain belts so as to prevent any interference between the crossed chains. The motor is securely mounted on the lower of the two main planes. The vertical flat piping, reaching from plane to plane, and seen to the left alongside the motor, is the radiator or water cooler, consisting of a number of small flat tubes.

The aëroplane is mounted on two wooden skids, which project forward and also beneath the aëroplane proper, and are utilised as a support for the front horizontal rudder. The whole forward structure is strongly braced with wooden struts and a specially tempered tough tie-wire.

The rough dimensions of the machine are as follows: The main planes are about 40 ft. long by 6½ ft. wide. These have a space between them of about 6 ft. It is estimated that the supporting surface is about 500 sq. ft. The horizontal rudder planes are each about 16 ft. long by 2½ ft. wide, and are shaped each on both its ends to a sort of point. The total surface in these two planes is about 75 sq. ft. Standing alone, without aviator or other added weight, the aëroplane weighs about 800 lbs. With the aviator and one additional passenger, together with a supply of fuel and water, it is estimated that the weight would be in all about 1,150 lbs.

The engine is a vertical four-cylindered, water-cooled gasoline motor, planned to be run at a constant speed of about 1,400 r.p.m. It is understood that it is so geared that at this speed it will drive the propellers, which are from 6 to 8 ft. in diameter, at about 500 r.p.m. Mr. Wright uses no carburettor, but draws his gasoline into the cylinders above the inlet valves, and it is further understood that Mr. Wright's practice is not to change the speed of the motor at all after once it is in action, except to stop the machine.

The engine is placed with its shaft in a fore-and-aft direction on the lower plane. It is located along the side of the aëroplane's fore-and-aft centre line, with the aviator and passenger on board (these two men being located as shown in Fig. 3 on the two cushioned seats in this picture to the right of the engine), so that the load around this centre line is quite symmetrically disposed, and thus practically in balance.

No sparking plug is used in the "Fort Myer" aëroplane, but it is operated with a make-and-break spark from a small magneto at the back end close to the engine. Roughly speaking, the engine gives about 32½ h.p. at the above speed.

In the lower right-hand corner of Fig. 3 will be seen the aviator's seat; facing the picture, to the left of the operator's seat, is the seat for the passenger. There is a brace across the framework in front of both aviator and passenger, upon which their feet may rest.

The lever at the left hand of the operator controls the angle of the two parallel horizontal rudder planes at the front of the aëroplane. The twin levers closely adjacent each to the other at the right hand of the operator are in

* From the *Western Electrician*, Chicago.

XUM

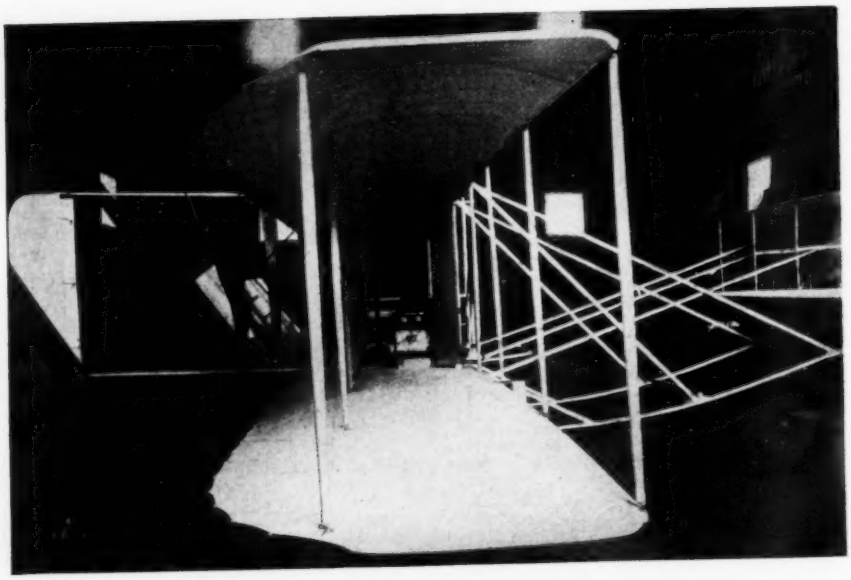

FIG. 1.—VIEW LOOKING INTO RIGHT SIDE OF THE "WRIGHT" AËROPLANE.

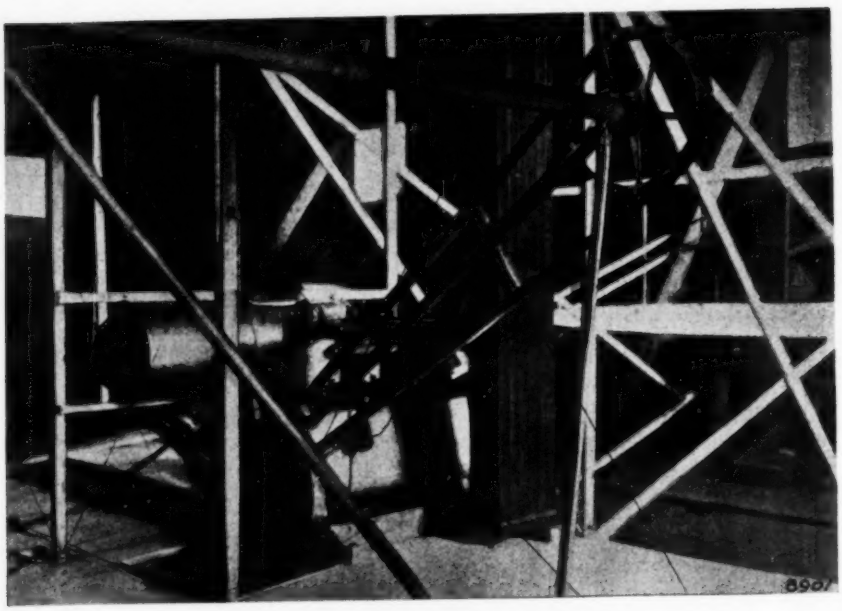

FIG. 2.—VIEW LOOKING DIAGONALLY FORWARD TOWARD FORWARD RUDDER.

control, respectively, of the machine's plane-warping mechanism, and also the vertical double-plane rudder at the rear.

A point to be remembered is that the speed of the aëroplane is varied chiefly by the changes in the angle of the aëroplane's lateral surfaces, and not by varying the speed of the motor.

Unbleached muslin is used for the aëroplane's surfaces.

The propellers are of wood, and especially curved according to tables calculated by the Wrights to obtain the maximum efficiency in air at a given speed.

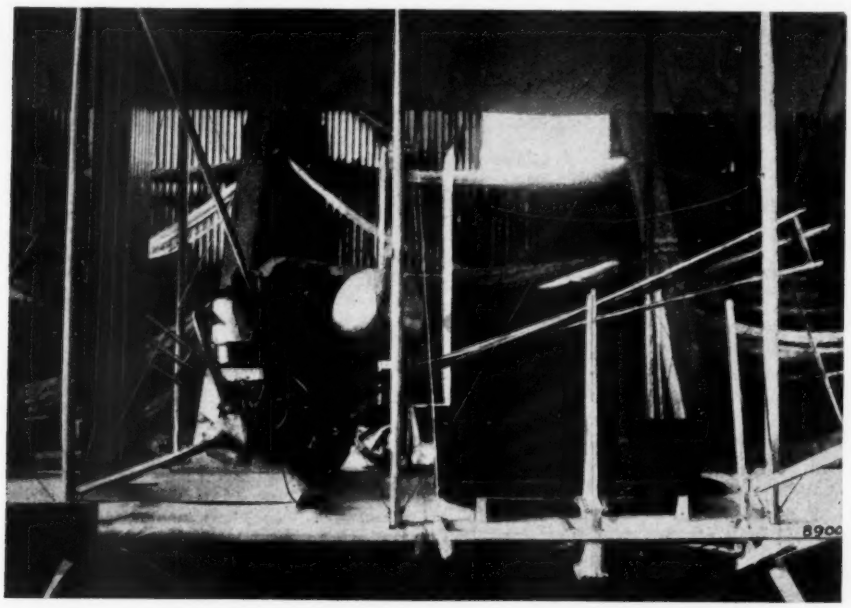

FIG. 3.—VIEW LOOKING TOWARD REAR RUDDER OF AËROPLANE.

The rear vertical rudder is stated to be never used alone for changing the direction of the machine; further, the sidewise balance of the machine is maintained through the warping of the two main aëroplane surfaces at their outer ends.

The New Dover Harbour Works.—Satisfactory progress is being made with the work on the New Admiralty Harbour at Dover, to which a visit was paid recently by the Society of Engineers.

The works were to be completed in ten years, or at the end of 1907, and although at one time there was every prospect of this being done, from unforeseen causes which arose as the work progressed, damage done by shipping, and various additional works, it will still be some months before they are finally completed.

The Admiralty Pier extension and east arm are completed, and during next summer the south breakwater will be so nearly finished that the viaduct spanning the east entrance will be removed, the larger part of the reclamation will be cleared and utilised by the Admiralty as a naval yard, provision being made for a submarine flotilla, so that for all practical purposes the harbour may be ready for service next summer.

It was towards the end of 1895 that the Admiralty instructed Messrs. Coode, Son & Matthews to prepare plans for a large enclosed harbour. As a result the following recommendations were made:—(1) That the Admiralty Pier should be extended 2,000 ft. in an east-south-easterly direction, practically doubling its length. (2) That an east arm, commencing a few hundred feet to the east of the eastern boundary wall of the convict prison, should be run in a direction approximately south by west for a distance of 3,320 ft. (3) That an isolated breakwater, 4,200 ft. in length, should run generally west by south and east by north, but turning towards the north at its eastern end,

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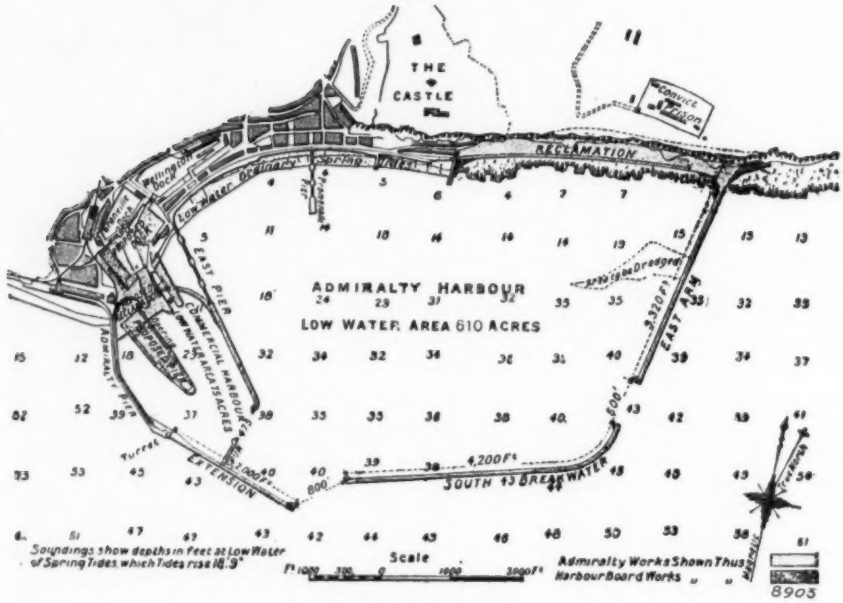

PLAN OF DOVER HARBOUR.

and should form the southern protecting arm. These recommendations are all shown on the accompanying plan. The average depth at low water of ordinary spring tides on the line of the southern breakwater is 42 ft. In addition it was recommended to reclaim 21 acres of the foreshore. The suggested arrangement of breakwaters left an entrance of 600 ft. in width between the east arm and the south breakwater, and an entrance 800 ft. wide between the extended head of the Admiralty Pier and the south breakwater. Both entrances have a depth of about seven fathoms at low water of spring tides, which rise 18 ft. 9 in.

These proposals were accepted, and the contract for the construction of the harbour was let in 1897 to Messrs. S. Pearson & Son. The total length of the sheltering works to be constructed is 9,520 ft., and the area enclosed, exclusive of the Commercial Harbour belonging to the Dover Harbour Board, will be 610 acres at low water, 322 acres being outside the five-fathom line, and 171 acres outside the six-fathom line. The project put forward by the 1840 Commission embraced a harbour containing a total of 450 acres, of which 320 acres would have been seaward of the two-fathom line. We may here mention that the area of the Commercial Harbour, which was originally to be 56 acres, will, when the works are completed as altered, be 75 acres. It will be seen that the end of the Admiralty Pier Extension is some 400 ft. to 500 ft. south of the western end of the south breakwater. This arrangement has been made with the object of helping vessels entering the harbour when the tide is setting eastwards at its greatest velocity. At such times the speed of the current is nearly four knots. It will also be useful during south-westerly gales.

In its present state it is difficult to realise the magnitude of the temporary works which were necessary to put in place the 1,500,000 cub. yds. of concrete and the 3,000,000 cub. ft. of granite. To do this four and three-quarters miles of double-line railway track has been built on staging in the open sea, subject to whatever the weather offered, the plant to handle this material having reached at one time 2,500 tons. The losses due to the action of the sea, both to permanent and temporary work, have been very small. A worse enemy to progress, and one which is always present, has been the tidal currents, as they so limit the time in which divers can work, and, of course, the tidal rise and fall interfere with all work between high and low water. Under these conditions a short visit might be paid to the works, even when in full progress, without seeing any work being carried on, or but little of any great interest.

In addition to what can be seen of the breakwaters above, there is an apron all round the

outer toe, consisting of concrete blocks of about 12 tons each, covering a width of 25 ft., for protection against undermining.

The Harbour Board are about to have constructed a widening of the shore end of the Admiralty Pier, on which a large station is to be built for dealing with the cross-channel traffic, and also a timber staging, 800 ft. long and 20 ft. wide, alongside the Admiralty Pier Extension, for the use of the Atlantic liners, with a passenger shelter and platform adjoining.

With these additions, and the Naval Harbour in use, Dover should become an important shipping port.

Mechanical Traction on Tramways and Roads.—In the course of an interesting paper on this subject, read before the Society of Engineers by Mr. H. Conradi, the author remarked that use of steam had never been allowed to develop fairly and firmly, and the local authorities seem to have done their best to hamper its service. Also the Tramway Act of 1870 proved a creation to the detriment of private enterprise. This was followed by the introduction of electric traction, with its different methods by underground or slot-conduit, by surface contact, and by overhead wire; the latter, being the cheapest in cost, was therefore more generally used. The author mentioned that in competition with tramway traction, on account of the permanent way construction, along the ordinary roads, mechanical traction on common roads was again thought of, seeming to be preferable, requiring no rails along the roads. It made rapid development, as now seen in the production of petrol, steam, and electric motor omnibuses and private carriages. The use of the motor omnibuses especially, but also of the private carriages, created, however, many unforeseen and unexpected evils, as destruction of the roads, unhealthy smells from burnt petrol vapours, depreciation of property in towns and country, the destructive nuisance of enormous dust waves, dangers to life of the public, and many other grave difficulties. All these grave difficulties, so detrimental to the public in general, would have to be overcome if mechanical traction on common roads is to become useful and beneficial to the public. The author then mentioned the necessity of consolidating the roads, and especially of finding means to prevent the raising of such tremendous dust waves, so destructive to all kinds of property in town and country. As to electric traction, the author said the destructive wave motion of the rails would have to be overcome. Details were given of the different kinds of French, American, German and English life-guards in use. Reviewing in conclusion the different methods of traction on tramways and common roads, the installations required in all its details for electric traction, those of motor omnibus garage, the very great number of breakdowns along all the roads, with permission by the local authorities to undertake temporary repairs on the road which was never permitted during steam tramway traction, the writer maintained that steam tramway traction, properly conducted, seemed still to be capable of holding its own against electric and motor omnibus traction, under the same conditions and if the same facilities were given; cost of installation being less and cost of working being about the same, even rather less than more.

The New Daimler Motor.—Early last month an authoritative announcement was made by the Daimler Motor Co., Ltd., to the effect that they had decided upon an innovation in motor design for 1909.

By the courtesy of the Company we are able to give some particulars of the new engine, the striking feature of which is its freedom from valves, springs, cams, and small parts, and consequent absence of noise arising from the operation of valves of the mushroom type.

In appearance the new motor is puzzling. It resembles neither the familiar four-stroke type nor the two-stroke pattern. But for the fact that the inlet and exhaust pipes are attached to opposite sides of the cylinder near the top, one might mistake it for a two-stroke engine, as there are no projections from the casting. As, however, there are no external evidences of mechanism for opening and closing valves, the unfamiliar find it impossible to fathom the mysteries of its operation. There are no externally projecting moving parts excepting the crankshaft ends and the cross-shaft which drives the pump and magneto, and the motor bears every evidence of plainness and extreme simplicity. In fact, outside the spirals which drive the magneto, water pump and commutator, there are no gears, and so simple is the design and construction that not a single oil hole requires attention anywhere about its mechanism, lubrication being wholly effected from the motor base.

As will be observed by the sectional illustration, the design affords a regular shaped spherical explosion chamber, with no pockets or irregularities and every inch of the surface of which is machined. This, it is fairly claimed, affords uniformity of volume, contributing to even explosive pressure throughout the various cylinders of the motor, and renders possible high compressions without danger of pre-ignition.

The design also permits a direct and unobstructed passage for the swiftly moving gases. The fresh charge enters the cylinder without encountering obstructions which would cause it to become heated and lose weight, while the exhaust is permitted an unimpeded path to the pipe, which is of liberal dimensions resulting in remarkably small heat absorption to the cooling water. Hence the matter of cooling the water is one of extreme ease, while the possible intake port area permits the filling of the cylinder with fresh gases at any motor speed desirable, as there is practically no limit

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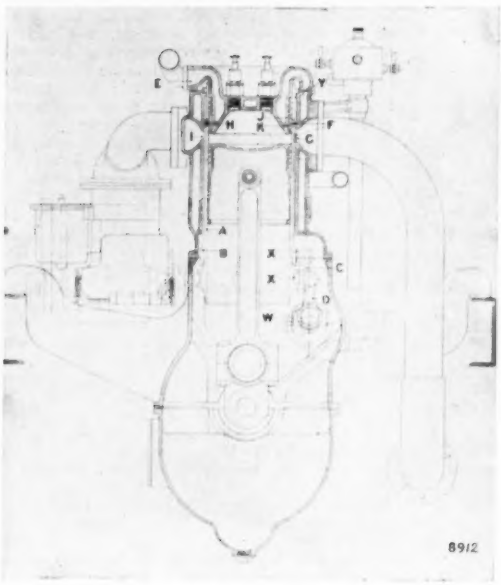


DETAILS OF NEW DAIMLER MOTOR.

to the size of the openings which can be secured with this construction.

The use of a cast iron sleeve as that portion of the combustion chamber in which the piston travels, permits the use of a cylinder machined inside and out to uniform thickness, thus reducing any tendency to warp or go out of shape under heat.

Another feature is the detachable head which forms the dome of the explosion chamber and carries the sparking plugs and compression rings. The removal of this head is only a matter of a few minutes, which permits easy cleaning out of any carbon deposits from the piston or combustion chamber walls, or the piston and connecting rods may be drawn upwards and without removing the cylinders from the base.

Lubrication is effected entirely from splash, oil being fed into the base chamber and distributing to the sleeves, pistons and all internal mechanism by the dipping of the connecting rod big ends. The motor was originally designed for lubrication higher up in the cylinders, but this was found unnecessary and undesirable.

By referring to the lettering of the accompanying sectional drawing, and the following description, a fair idea of its character and workings may be obtained :—

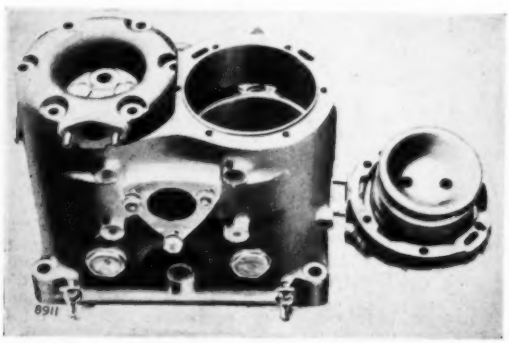
Instead of poppet valves, two thin moving cast iron sleeves, *A* and *B*, are made to work together in an outer water-jacketed cylinder. These sleeves, or cylinders, are actuated by separate eccentrics on the secondary one-to-two shaft *W*, through the connecting rods *C* and *D* attached by gudgeon pins to the lugs *X*. *L* is the water-jacketed cylinder head, resembling an inverted piston, carrying the sparking plugs and a wide packing ring, *J*, in two sections held out against the inner walls of the sleeve *A* by the inner ring *K*, which is split in one place, as in the common piston ring.

The piston travels in the cylinder *A* with a stroke of 130 mm., while this cylinder *A*, as well as the outer sleeve *B*, travels 25 mm., the eccentric which actuates cylinder *A* being set 70 deg. on the circle head of the eccentric, which pulls the outer sleeve *B*.

In operation, beginning with the exhaust, the process is as follows :—

The piston travels downward on the explosion stroke until it reaches a point where it is desired to exhaust. At this stage of the operation the sleeves *A* and *B* have moved downward until the lower lip of the exhaust parts *F* passes behind the compression ring *K*. The continued downward movement of the sleeves *A* and *B* completely uncovers the exhaust port *F*. This port remains open until the piston reaches the top of the scavenging stroke, when it is closed by the upper lips of the port *F*, in the sleeve *B*, telescoping with the lower lip of the exhaust port *G* in the water-jacketed cylinder.

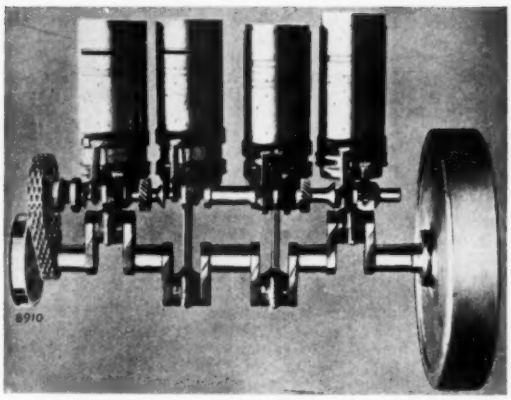
As the piston starts downward on the suction stroke, the ports *F*, through the eccentrically-actuated sleeves,



VIEW SHOWING CYLINDER CASTING AND DETACHED HEAD.

move away from each other and the opening in *A* is closed by the wall of *B*. This same movement brings port *H* into register, thereby opening up the inlet port and forcing the filling of the cylinder through the carburetter.

When the piston starts on the suction stroke the sleeves begin their upward travel; having reached the bottom of their outward stroke, the movement of the sleeve *A* is so timed as to carry the inner port *H* upward behind the ring *J* just after the piston has reached the lower end of the suction stroke. This closes and tightly seals the cylinder while the piston returns on the compression stroke, the pressure of the gases aiding in keeping the ring *J* tightly over the ports *F* and *H* until the explosion occurs, which, if timed for dead top centre of the crank, would find these upper ports over the centre of the ring *J*.



VIEW OF THE SLEEVES SHOWING METHOD OF OPERATION.

The sleeve mechanism peculiar to this construction is said to require very little attention, and particular claim is made for regularity of compression, loss in this respect being said to be unknown during the life of the rings.

Three sizes of this design are now in course of construction at Coventry, viz., 96 × 130, 124 × 130, and 140 × 150 mm. The small motor is designed for a light touring car, the 124 × 130 is calculated to answer all ordinary requirements for power and speed of a medium weight car, while the 140 × 150 is for the heavier work. Cooling of the 96 × 130 size will be accomplished through thermo-syphon, and the two larger models with centrifugal pumps. Crankshaft, connecting rods, and bearings are "Daimler" standard construction, and there is no radical departure from standard practice in ignition.

Repairs, Renewals, Deterioration and Depreciation of Workshop Plant and Machinery.*—Most of the details of the management of an engineering establishment have, within recent years, been systematised. Systems now govern general office, drawing office, and works, from the filing of correspondence onwards; and no modern business can be economically carried on without them.

It therefore appears strange that the method of dealing with the wear and tear, repair and renewal, and depreciation of plant and machinery, has escaped attention, and that there seem to be as many different ways of treating this question as there are engineers, or perhaps it should be said, as there are accountants.

The matter is very far from being, as many seem to believe, merely a matter of accountancy; in fact, the first reform would be to transfer the control of the machinery stock book, and everything connected with it, from the accountant to the engineer.

It is beyond dispute that the efficiency of a manufacturing establishment depends upon the quality and condition of the plant and machinery therein, and that any neglect to maintain this equipment in the highest working condition promptly results in a falling-off in both quality and quantity of output. The first question, therefore, to be considered is: What is the best system to be adopted for maintaining the whole factory equipment in proper repair, and for discarding obsolete or worn-out machines and replacing them with new machines when necessary? The second question is that upon which opinions differ so greatly, viz: How is the necessary financial provision for the maintenance and renewal to be made? Needless to say, the two have to be considered together.

Maintenance.—The maintenance of the plant and machinery of a manufacturing establishment is generally one of the duties—and not the least important one—of the works manager, and much depends upon his judgment in deciding upon and executing the necessary repairs and renewals from time to time. It is, however, very unusual for this official to have any concern with, or knowledge of, the money value of the plant he is dealing with, and there would be an obvious advantage in the introduction of the reform previously indicated; placing the control of the repairs and renewals and of the valuation in the same hands, and limiting the accountant's duty in this connection to the use of the valuation provided for him by the engineer for the purpose of his profit and loss account and balance sheet.

Under the suggested system the control of

* Abstract of a paper by J. E. Darbishire, read before the Institution of Mechanical Engineers.

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everything would be vested in the works manager, or, in the case of large works, in a special official. The limit of his powers, as regards incurring expenditure, would be defined by the general manager, directors, or partners, according to circumstances; he would be responsible for the upkeep of the whole of the machinery and plant, and it would be his duty to report his requirements when he found them to exceed his financial limit; but it is essential that he should have considerable latitude in incurring expenditure on repairs, because obviously time is of the utmost importance in most cases, and he ought not to be bound by too much red tape; in machinery repairs "a stitch in time" often saves many times nine. There is no doubt whatever that if the right man be appointed there will be no difficulty on this point.

His first step must be to prepare a proper schedule of the plant and machinery in his charge, entering each item in the machinery stock book, with its distinguishing number. Against each item there should be entered its present value, calculated according to its age, in the manner to be explained later. Also a figure representing its *probable life* in years; this second figure will be required when provision or depreciation comes under consideration.

The importance of properly estimating probable life will be apparent when depreciation is considered, and it is in this that the engineering skill and experience of the works manager or the special plant engineer will have their opportunity. The matter seems to have had no consideration whatever in the past; but a short time will suffice to produce plenty of men with the experience necessary to form a sound judgment on the probable life of any machine, that is, on the chances of its becoming obsolete by the arrival of new methods of working, and also of its wearing out in use.

The next step must be to make provision for proper care of the various machines, and for repairs being executed when required without delay. To ensure this, each attendant or workman in charge of a machine or group of machines, being the actual attendant or operator, and not a foreman, would be made, in the first instance, responsible for its being maintained in the highest possible condition, the fireman for his boilers, the turner for his lathe, and so on. It would be his duty to report immediately to his shop foreman any defect becoming apparent, and to enter on a card the description and number of machine, nature of defect, date, and his (the attendant's) name.

The foreman's duty would then be to inspect the machine, and if in his opinion the repairs are necessary, to initial the card, and submit it to the works manager for final authority, the works manager initialling and dating the card and assigning a works order number to the job. The repairs would then be executed at once, and on their completion the machine would be inspected and passed by the works manager, and their execution certified (with date) on the card; to which would be also added the cost incurred. This system would ensure proper care by the attendants of every machine, and would prevent ill-usage, which used to be one of the workshop troubles, though in this respect the modern workman is a great improvement on his predecessors, and the care of machines—especially machine tools—now leaves very little to be desired. It would also afford the works manager the opportunity of deciding when the time has come to replace instead of repairing—and it will be remembered that this official would have before him the "stock book" valuation of the machine under consideration, and therefore would know how far the cost of renewal had been provided for. He would see the whole situation at a glance, and decide whether to replace, thoroughly repair, or partially repair.

In addition to the workman's or attendant's daily watching of each machine, periodical inspection should be made by the works manager as a check upon workman and foreman, and each such inspection recorded.

Depreciation.—It is sometimes argued that if machinery be maintained as indicated above, it does not depreciate, and that, so long as its output does not fall off in quality or quantity, it is as valuable to its owner when ten or twenty years old as when new. This, however, is absolutely incorrect, for although a machine could of course be kept "alive" for ever, by renewing its parts one by one as they wear out, supposing that it never grew obsolete its value at any given time would depend upon the state of deterioration of its various parts at that time, because since each part has a "life," the effluxion of the life of that part is proceeding from day to day. But machines do grow obsolete, and are not renewed in this way; and the depreciation now to be considered provides for that effluxion of life of each machine as a whole which actually takes place, the amount depending upon the time which a machine can be profitably used for the purpose of producing the output required by the works in which it is installed—this being its "life."

It is therefore absolutely necessary to make provision for a fund by means of which the various items of a workshop equipment can be renewed from time to time—which provision obviously has to be made without any reference to the profits or losses of trade. It must be made as part of the working expenses of the business, and in this respect the author protests against the system frequently adopted by accountants of showing a so-called "profit," out of which so much is set aside for depreciation, the amount apparently being at the discretion of the directors or the accountants, and frequently depending upon the amount of the so-called "profit." It is clearly wrong to make the provision for depreciation a charge on profits, for depreciation is really a loss of the capital assets, which has to be made good out of income, and is just as much a charge on

revenue as rent or taxes; there is no escape from its incidence, and there is no profit until adequate provision for depreciation has been made. That the provision should be adequate goes without saying; the amount must be determined without reference to the result of trading, but must be an absolute charge, so that the depreciation may be truly representative of the loss of value of the machinery, which occurs whether trading is profitable or not.

When therefore a machine is new, the probable life having been estimated, the depreciation on that machine can be determined, the sum of the loss during life being the new value less the scrap, or ultimate value. This has to be written off during the life in gradually decreasing increments by fixing a percentage to write off each year from the last year's value, this percentage being such that at the end of the life the depreciated value shall equal the scrap value.

It must be noted that the ultimate values of machines expressed in percentages of their new value vary considerably, because an expensive special light tool will probably have a lower scrap value than a much less expensive heavy tool, such as an ordinary planing machine or a heavy lathe.

It is clearly impossible to foresee either probable life or ultimate value with absolute accuracy, and it would be a refinement of detail to treat each machine on a basis of its own, even if it were possible; but having estimated the probable life and ultimate value individually, each machine may, for depreciation purposes, be assigned to one or other of the classes indicated by the curves on Fig. 1, the class selected being that giving the nearest resultant scrap value at the end of the probable life.

Such a provision as the above is sufficient to cover loss due to deterioration beyond that made good by repairs; because, in estimating probable life, the chance that a machine may wear out before it becomes obsolete is taken into consideration.

It must, however, be borne in mind that special conditions apply, in the case of leasehold premises, to certain machinery which passes with the hereditament; and when the period of lease is shorter than the probable life of any such machinery, it becomes necessary to apply a rate of depreciation which will *entirely* extinguish the valuation at the expiry of the lease, not even scrap value remaining. In such a case, it is simplest to write off an equal instalment each year, dividing the present value by the number of unexpired years of the lease.

The amount of depreciation on each item being determined, the total on the whole plant must be charged against the income of every year, if the balance sheet is to show truly the value of the plant, and consequently the actual profit or loss of trading.

The author believes that it is essential to schedule every item, and to write off the depreciation separately, so that the stock book may show the actual present value of every machine. It may prove, in the course of a machine's career, that for some unexpected reason it is found that its life is likely to fall short of, or to exceed, the estimate to some considerable extent. In such a case there is no reason why it should not be considered on its merits, and the rate of depreciation increased or reduced from the time when its unexpected weakness or vitality became apparent. This would provide against the absurdity of a useful machine standing in the stock book at scrap value. But any changes in depreciation should only be made with authority; accurate judgment in estimating probable life will prevent such cases occurring.

When a machine is replaced it disappears from the stock book, and its successor takes its place at its new value, being paid for out of the accumulated funds. Thus the valuation would

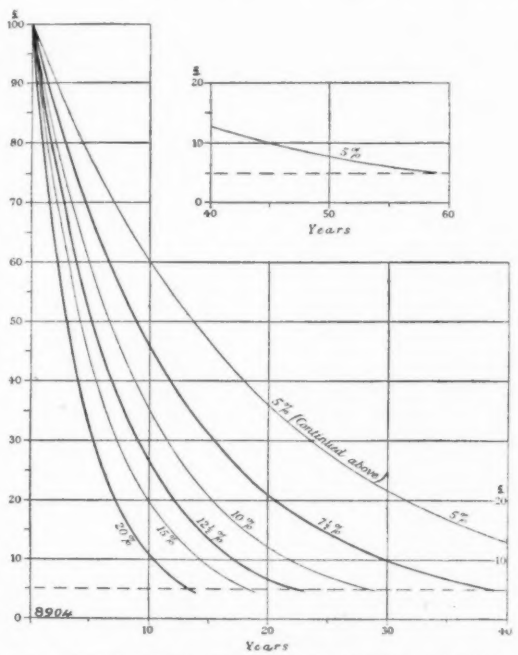

FIG. 1.—CURVES SHOWING DEPRECIATION OF MACHINERY ASSUMING A PROBABLE LIFE AND SCRAP VALUE.

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be unchanged in the event of new machines replacing old ones to the exact extent of the total sum set aside for depreciation in any year.

There is still a provision to be made for the cost of repairs, which is usually met out of income, as it is incurred each year. This is perfectly sound in works which have been established for some time, but in the case of new works, equipped with entirely new plant—as the repairs for the first year will be practically *nil*, and for the next few years very slight, whereas they will fall heavily on some later years—it is wise to set aside a sum during each of the early years to provide for this. After a few years, the requirements for repairs equalise themselves, owing to the varying rates at which the different items require expenditure.

Increase in the productive power of works due to the installation of additional machinery warrants a charge upon capital, and such machines appear in the stock books as additions to plant, although no additional capital may have been raised to pay for them.

If additions to individual machines increase their productive capacity, the cost of such additions may fairly be added to their stock book value, but they must then be depreciated at such a rate that the additions are written off by the end of the life of the machine.

The results of unsound finance in dealing with depreciation are so serious that it may surely be said that every establishment ought to be put on a sound basis, the actual present value of the machinery and plant determined, and systematic provision made for depreciation, so that when renewals become necessary their cost is provided for. It is often stated that when a business is working at a loss there can be no provision for depreciation, which in a sense is true; but depreciation is going on all the same, and the accounts ought to show the loss fairly and squarely—that is, the depreciation sum should be written off whatever the results of trade. If a recovery takes place, the position is sound; if not, continued losses mean the end of the business, and the valuation of the plant at its right figure will not affect this.

As a matter of accountancy, in order that the balance sheet may show the true value of the plant, this should be entered at its depreciated value; the depreciation should not be treated as a separate or "reserve" fund, though if this separate fund be sufficient, the financial position is quite sound. The essential thing is that it should be sufficient, and that it should be provided for before the word "profit" is as much as thought of. This means that the statement or valuation must show the real value of the plant and machinery.

Depreciation as a charge against revenue is admitted in principle by the income tax authorities, and in rating valuations the rateable machinery and plant are assessed at their depreciated value. This, however, is a somewhat thorny question, and although the author feels that it should not pass unmentioned, it is perhaps hardly one for consideration in connection with the present subject, which is that of workshop practice as affecting the effective maintenance and the true valuation of machinery and plant.

The Manchester Electrical Exhibition.—The Electrical Exhibition held in Manchester during the past month under the auspices of the Corporations of Manchester and Salford, in co-operation with other corporations interested in the supply and distribution of electricity, was a worthy successor to the first exhibition organised by that industry, and held at Olympia, London, in the fall of 1905. It will be remembered that the latter was promoted by the National Electrical Manufacturers' Association, under the patronage of the Institution of Electrical Engineers, and various supply companies and municipal authorities, and achieved an unlooked-for success. The present exhibition was the outcome of a desire expressed in many quarters for a similar comprehensive display of electrical plant and fittings in the large and important industrial district of which Manchester is the centre, and the fact that over 250 representative exhibits were displayed by leading firms in the trade, shows how fully the hoped-for result has been achieved.

Of outstanding novelties there were few, but the exhibits served to mark more particularly the rapid progress made during the past three years in the flame arc lamp, the metallic filament lamp, and the application of electricity for the driving of textile machinery. The space at our disposal forbids more than a brief mention of the more striking of the exhibits, of which the practical demonstration of the Brown-Boveri system of ring spinning appeared to claim the first place. Two spinning frames were shown at work, one arranged to spin cotton weft on to very thin paper tubes, the other to spin cotton weft on to centrifugal clutch spindles suitable for use in the shuttle of a Northrop loom. Each was an ordinary standard frame of its own type, and the tin roller shaft of each was driven by a separate single-phase commutator motor controlled by its own automatic gear of special design and construction. The automatic gear is driven by the headstock of the frame, and in its turn varies the speed of the motor, so that the speed increases as the ring-rail of the frame falls, and decreases as it rises. In this way the speed of the whole frame is continuously varying with the rise and fall of the ring-rail, and the variation is such that, it is claimed, the tension on the yarn being spun is always constant; to keep it so, the speed has to increase very considerably when yarn is being wound on to the shoulders of the cops, and this results, it is stated, in a much greater output from the frame than if it were run at one constant speed. This system therefore not only improves the spinning, but, as the tension is not as great as that reached when a constant speed is employed, fewer ends are broken.

The British Thomson-Houston Co. also

furnished an example of textile driving in the shape of a complete ring-spinning frame, by Brooks & Doxey, containing 52 spindles with a 5 in. lift and driven by a 7½ h.p. three-phase induction motor. Messrs. Siemens Bros. showed a loom motor driving a loom by Messrs. R. Hall & Sons, and an electrical gassing frame in which the superfluous fluff is singed off the cotton by means of split platinum tubes raised to a white heat by electric current. Hitherto a gas flame has been employed for this operation. A portion of the fine exhibit of Electromotors, Ltd., of Openshaw, also illustrated the application of electric driving in textile machinery, consisted of two quick-traverse winding frames for winding cotton and other yarns.

Amongst the prime movers shown was one of the two first Zoelly turbines which have been entirely manufactured in England, having been built complete in every part at the works of the exhibitors, Messrs. John Musgrave & Sons, Bolton. This machine, which gives 750 h.p., is direct-coupled to a Siemens 600 kw. three-phase alternator. The high-pressure end of the turbine was exposed to view by substituting for the upper half of the cast iron casing one of glass through which the whole of the interior could be seen. It is a duplicate of a set at present installed at Falcon Mill, Bolton, a factory of some 100,000 spindles. On another part of the stand was an electrically-driven barring gear, intended for a 4,000 h.p. cross-compound vertical engine—the sixth installed—at the City of London Co.'s Bankside station. A Cruse superheater attached to the downtake of a Lancashire boiler completed the exhibit.

Readers may be reminded that the Zoelly turbine is of the simple impulse type in which the steam, having passed the regulating valve, is passed to a set of guides in which the steam pressure is turned into kinetic energy, to be converted into mechanical work by the steam being diverted on to the running wheel. This process is continued through a succession of guides and running wheels—each guide portion acting only on its own running portion—until the expanded steam exhausts into the condenser.

Each guide consists of a disc divided along its horizontal diameter. They are of cast steel or iron, and are made in one piece with the distributing ring. The disc in the low-pressure portion is of cast iron and the nickel steel guide blades are cast in. The blades of the running wheel are also of nickel steel. They are of great solidity and are thickened towards the base, so that the stress on the metal is the same at every radius. The method of construction and fixing appears to secure a high degree of reliability.

The Diesel heavy oil engine was well represented, not only at the stand of the company itself, but at that of Mirlees, Bickerton & Day, of Stockport, who staged a three-cylinder 150 b.h.p. engine driving a direct-current dynamo by the Lancashire Dynamo and Motor Co. With oil at 65s. per ton it is claimed that the cost of running per kw. hour at full load is only 0·26*d*. Gas engines were shown by the National Gas Engine Co.; J. W. Bates & Co., Manchester; Crossley Bros.; steam engines by Browett, Lindley & Co., Patricroft, and W. Sisson & Co., Gloucester; and turbines in model form by C. H. Parsons & Co.

Of steam accessories and plant there was a profusion, Messrs. E. Green & Co., Ltd., showing their widely known and used economiser, in model form complete with all piping, pumps, valves, dampers, etc., with scraper gearing in action, illustrating very completely how the surfaces of the economiser tubes are kept free from soot. Messrs. Hopkinson & Co., Ltd., Huddersfield, staged a full-sized model boiler, fully equipped with their safety boiler mountings, and an archway of pipes and valves for various apparatus; Sanders, Rehders & Co., Ltd., showed a full range of their CO_2 recording instruments and "Sarco" draught and pressure gauges. Particularly noticeable was a new gas volume recorder, attached to the gas plant shown by Messrs. T. H. & J. Daniels, Ltd., Stroud, showing the actual volume of gas used by the engine. This instrument, it may be mentioned, is specially designed to measure large volumes of hot or dusty gas which cannot be metred in the ordinary way. Packings were represented by Small & Parkes, Ltd., Harpurhey, who displayed a variety of their Karmal specialities for all pressures of steam, hot and cold water, acid and alkalies; and by the United States Metallic Packing Co., Ltd., Bradford, who showed numerous examples of their packing as applied to piston and valve rods of marine, stationary, and locomotive engines. Specimens were on view that had been in service for 16½ years without renewal.

A number of sets of metallic packing of various types showing the latest practice for high-speed engines were to be seen at the stand of the Combination Metallic Packing Co., Ltd., Gateshead, and the coloured wooden models showing these types in section formed a feature of interest. Amongst other engine-room specialities shown were the well-known "C.M.P." joint rings and mechanical force sight-feed lubricators.

The Lea Recorder Co., Manchester, showed several water recorders and accessories, amongst which may be mentioned a notch tank and 7 in. recorder of 15,000 lbs. per hour capacity. This was in operation, the water being supplied by a 3 in. centrifugal pump driven by a Westinghouse motor. Of interest was the model of a 100-ton refuse destructor shown by Messrs. Heenan & Froude, Ltd., Manchester, as erected by them for the Wood Green District Council. The firm also displayed a "Foster" superheater element, "Little" water cooler, and samples of clinker and slag from their refuse destructors.

Machine tools formed a conspicuous section of the exhibits, the firm of William Asquith, Ltd., Halifax, being represented by a 6 ft. central-thrust radial drilling machine, two

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3 ft. 6 in. radial drills, a rigid vertical drilling machine, and a 6 in. slotter. Alfred Herbert, Ltd, Coventry, as usual had a conspicuous and representative display of their automatic and semi-automatic tools, small tools, chucks, grinding wheels, &c. The collection included a No. 2 hexagon turret lathe for bar work up to 2¼ in. by 30 in., with single pulley head, driven by constant-speed motor. The machine was shown in operation producing bolts from the bar by means of a roller-steady turning tool; a No. 2 automatic turning machine, with self-selecting feed motion, driven by constant speed motor, and shown in operation finishing cast iron pulleys; a four-spindle patent ball-bearing sensitive drill, electrically driven; a No. 6 horizontal milling machine, with dial feed motion, 28 in. by 9 in. by 19 in., with two ratios of double gearing, and new method of locking knee from the front; and a No. 1 vertical milling machine, with dial feed motion, with circular table.

Frank Pearn & Co., West Gorton, varied their pump display by showing a No. 2 size electrically driven high-speed surfacing, boring, and milling machine, a similar tool figuring on the stand of Geo. Richards & Co., Ltd., Broadheath, whereon was also staged a 3 ft. vertical boring and turning mill and a No. 1 slot drilling and keyway cutting machine, fully automatic, and capable of dealing with keyways up to 1 in. wide and 20 in. long. Pollock & Macnab, Ltd., of Bredbury, occupied a large stand, on which figured the following "Apollo" tools:—Combination turret lathe for boring and chuck work up to 23 in. dia. and for bar work up to 4 in. dia.; capstan lathe for boring and chuck work up to 18 dia. and for bar work up to 2⅞ in. dia.; capstan lathe for boring and chuck work up to 13 in. dia. and for bar work up to 2 1/16 in. dia.; hexagon turret lathe for bar work up to 1⅝ in. dia. and 21 in. long; engine lathe, 17 in. swing with 8 ft. bed, with automatic traversers and leading screw. Two milling machines, a radial drill, and a No. 1 gear hobber completed the exhibit.

C. Redman & Sons, Halifax, showed a rapid planing machine fitted with the latest type of four-speed countershaft, giving four rates of cutting with constant speed return; also an extra rapid lathe, 10 in. centres and 12 ft. gap bed, specially designed for turning crank shafts, pistons and rods, and other gas and marine engine forgings. Other exhibitors in this class included Luke & Spencer, Ltd., Broadheath; H. Wallwork & Co., Ltd., Manchester; Meyer & Schmidt, Offenbach; Ludw. Loewe & Co.; Chas. Churchill & Co., Ltd.; C. W. Burton Griffiths & Co.; while portable electrically-operated tools formed the feature of the Consolidated Pneumatic Tool Co.'s exhibit on the stand of Steinthal & Boydell, Ltd., Manchester.

One of the most conspicuous stands in the hall was that of the General Electric Co., Ltd., who were well represented with metal filament lamps, flame arcs, motors, 500 kw. generator, telephones, bells, switchboard, instruments, &c. The British Westinghouse Co., Ltd., Trafford, were also well represented in most of their departments of manufacture, whose display, together with those of such firms as Siemens Bros., Ltd., Robertson Electric Lamps, Ltd., Bruce Peebles & Co., Ferranti, Ltd., Morris Hawkins, Ltd., Lancashire Dynamo and Motor Co., Ltd., Drake & Gorham, Ltd., R. W. Blackwell & Co., British Thomson-Houston Co., Ltd., &c., &c., included most forms of electric lighting, power, motive, heating and cooking apparatus that is now placed at the convenience of engineers and the public.

In conclusion, mention may be made of the fine display made by Glenfield & Kennedy, Ltd., Kilmarnock, of such specialities as sluice valves for water, steam or exhaust, stop valves, electric water level indicators and recorders, &c.; also that by the Vincit Co., Ltd., 67, Aldersgate Street, who, amongst their carborundum and electrite specialities, showed some carborundum resistance rods for forming resistances of from 10 to 200,000 ohms. Time registers for recording the ingoings and outgoings of employees, time spent on jobs for cost keeping purposes, were well represented at the stand of Dey Time Registers, Ltd., 75, Queen Victoria Street, E.C. Mention must also be made of the stand of a local firm, Messrs. Matthews & Yates, Ltd., Swinton, whose collection included fans for general ventilation, electric blowers for plenum and exhaust ventilation by trunks, belt blowers for refuse collection, and blowers for hearths, cupolas, &c.

TRADE LITERATURE.

Consett Iron Co., Ltd., Consett, Durham. Price list of sectional steel.—Hines' Patents, Ltd., Glasgow. Pamphlet descriptive of Hines' new wage calculator.—Alfred Herbert, Ltd., Coventry. Sixth edition of the firm's booklet on horizontal and vertical milling machines. Two new sizes of machines are illustrated: the No. 3 Horizontal Milling Machine, 21 in. × 17 in. × 16 in., which is a medium sized machine, very convenient in operation, possessing the power and rigidity requisite to take heavy cuts with high speed steel cutters; the No. 5 Patent Vertical Milling Machine, 48 in. × 18 in. × 26 in., with single pulley drive; a number of useful attachments and accessories; also a number of milling machine operations, both horizontal and vertical, which should be of service by suggesting methods for handling similar work.—Scherzer Rolling Lift Bridge Co., Chicago. Catalogue of the firm's rolling lift bridges.

Machinery, Appliances and Processes.

The Editor invites advance particulars, drawings, blue prints, photographs, and any data that will enable him to publish an adequate description in these columns of any new work, machinery, or installation, possessing special features of interest. The cost of publication and engraving is borne by us, and no compensation is expected. In the endeavour to produce a really high-class and technically valuable machinery section the Editor seeks the co-operation of engineers and manufacturers.

Testing Machines for the Glasgow Technical College.

Messrs. W. & T. Avery, Ltd., of the Soho Foundry, Birmingham, have just erected at the Glasgow and West of Scotland Technical College one of the most up-to-date sets of testing machinery.

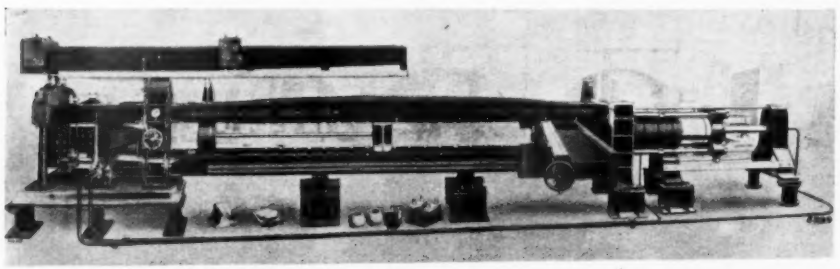
This comprises three different machines, each of which has its own special advantages, and as far as this country is concerned we are unaware of anything approaching this combination for completeness of the application of the different tests that metal requires.

The principal machine is a 100-ton horizontal testing machine, and is arranged for giving tests in tension, compression, transverse, and shearing. This will be mostly used for testing columns and beams as well as ordinary specimens. The specimen in tension will be of a maximum stretched length of 15 ft. 6 in., the columns can be tested in compression to a maximum length of 15 ft., beam specimens can be tested transversely to a span of 15 ft., and the shearing will admit of specimens having a section of 4 in. by 2 in. in double shear. It will also be capable of testing hemp and wire ropes of a stretched length of 15 ft. 6 in.

Without entering into a full technical description of this machine, we may say that it is of the horizontal type, and one of its special characteristics is that the straining racks are in tension in all tests. Another feature that is worthy of note is that a protracted test can be made, as, after the required strain has been applied, it may be kept under strain for any given length of time.

When we mention that the graduations are so arranged that a reading can be given from $\frac{1}{2000}$th of a ton to 100 tons, it will be seen that the uses of this machine will be as complete as they are varied.

In machines of this character and capacity, one of the most important parts are the knife-edges and bearings, and undoubtedly the experiments and experiences



100-TON HORIZONTAL TESTING MACHINE.

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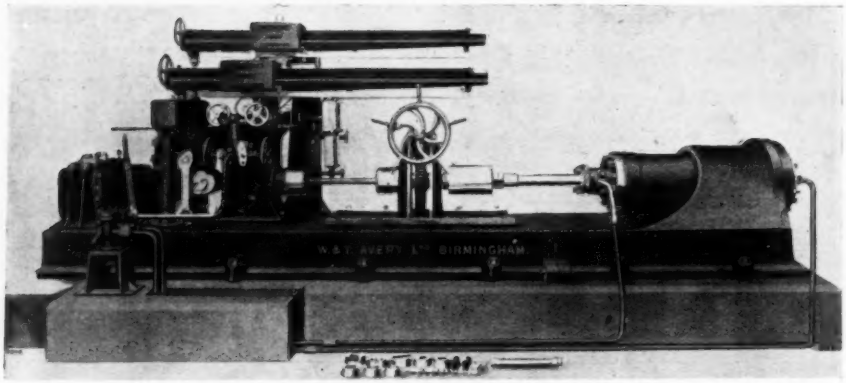


TENSION-TORSION TESTING MACHINE.

of Messrs. Avery, Ltd., in the manufacture of their weighing apparatus have served them in good stead as applied, in this instance, to testing machinery.

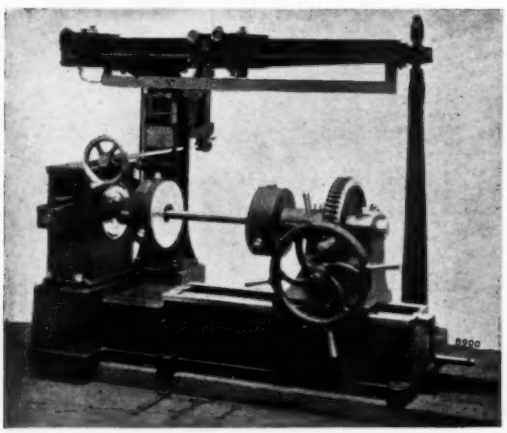
The second machine is a tension-torsion testing machine, which is designed to apply combined tests in tension or torsions, either simultaneously or separately.

The capacity of the tension test is 56,000 lb., and the torsion 12,500-in.-lb.

This machine has been specially designed to meet a very growing requirement in testing bar specimens. The tensile strain is applied by means of a hydraulic cylinder and ram, the torsion strain being applied by means of a handwheel. This necessitates two independent weighing systems, and they are indicated separately on their own steelyard. The specimens may be of any desired section up to 1 in. diameter, and the maximum stretched length between the holders is 36 in. During each combined test two diagrams will be drawn simultaneously upon squared paper mounted upon two separate drums, and, as previously noted, these tests can be made quite separately and independently.

The third machine, which completes this set, is a reversed torsion tester. This will apply tests to bar specimens torsionally in either direction of twist. This machine has a maximum capacity of 15,000-in.-lb.

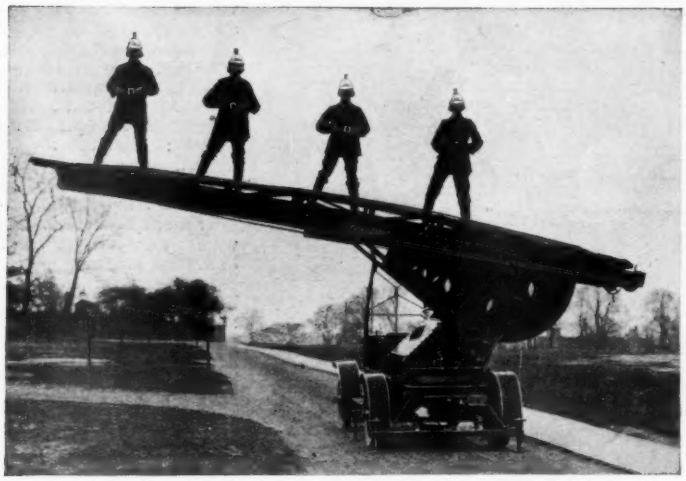
With a very greatly increased attention which engineers are now giving to the testing of metal, no doubt these machines will be greatly appreciated and lead to further and increased results in this interesting branch of engineering.



REVERSED TORSION TESTING MACHINE

A Motor-Driven and Motor-Worked Fire Escape.

The accompanying illustration shows a remarkable fire escape which has recently been completed by Messrs. Merryweather & Sons for the Shanghai Fire Brigade. It is on the turntable principle,



MOTOR-DRIVEN AND MOTOR-WORKED FIRE ESCAPE.

motor-propelled and motor-worked, and may justly be claimed to mark an epoch in fire engineering. It is true there are other motor-propelled turntable escapes, but this machine is the first one to be made in which the engine which propels the carriage is also employed for raising and extending the ladders.

The carriage is propelled by a 40-h.-p. four-cylinder water-cooled petrol motor, giving three forward speeds and one reverse, a maximum of 25 miles an hour on the level being attainable, whilst 1 in 5 gradients can be negotiated. The wheels are of the artillery pattern, fitted with solid indiarubber tyres, those in rear being of twin section. The ladders are four in number and extend to a total height of 80 ft. In the travelling position they rest horizontally on the carriages, but on reaching the scene of operations the power of the propelling motor is transferred to the escape machinery through a vertical worm fixed on the centre line of the turntable, and the raising and extending of the ladders to their full extent is effected in less than a minute. These operations can be carried out entirely by one man through two levers arranged side by side at the rear of the machine. The raising and extending of the ladders can also be performed by hand mechanism, alternative gearing being provided for this purpose. The turntable is worked by hand gearing, and enables the ladders to be slewed round to either side of the carriage within the radius of more than a semi-circle. Our illustration shows the action of the turntable, the ladders being slewed at right angles to the carriage. Plumbing gear is fitted, enabling the ladders to be tilted sideways on the ladder framing, an advantage which can be appreciated when the carriage is standing on a hillside or other uneven ground. The sides of the ladders are fitted with Merryweathers' patent bowstring girder truss of light steel tube, which, besides materially strengthening the ladders, forms a convenient handrail, which is a great advantage when the height of the escape is taken into consideration. Special attention has been paid to stability, and it may be mentioned that the ladders can be extended horizontally to a distance of 50 ft., at right angles to the carriage, and will then safely support two men on the extreme end without fear of tilting the carriage. The rear portion of the frame is fitted with two cross members, carrying screw struts at their ends, which can be screwed hard on to the ground, so as to take the weight of the machine off the carriage springs and afford a solid base for the escape when in use.

A great feature of the machine is its adaptability for working in confined spaces. The ladders can be raised, extended, adjusted to any angle, and slewed round as desired, and any point within the range of the ladders reached with the utmost certainty.

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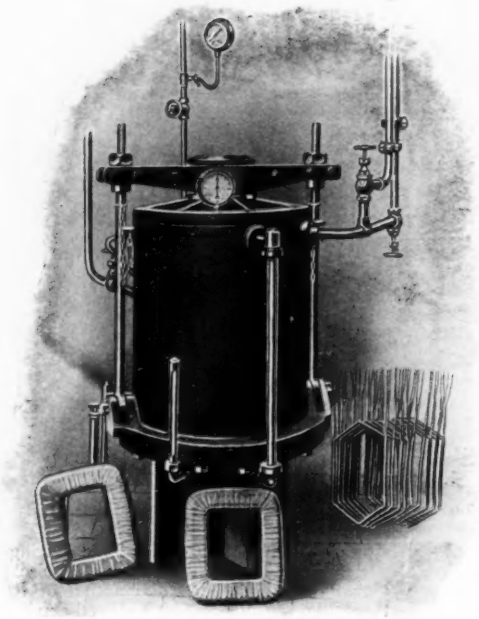


DRY INSULATING MACHINE.

This fact was amply demonstrated prior to the escape being shipped abroad. It was taken to London and got to work in Bow Lane, perhaps the narrowest and most confined of the city streets, when the various operations of the ladders were carried out without the slightest difficulty.

Shanghai deserves every credit for its up-to-date policy in regard to Fire Brigade material, and doubtless similar machines will ere long be found in the United Kingdom, where the use of self-propelled fire appliances is advancing by leaps and bounds. It was clearly demonstrated how invaluable such an apparatus would be for operating in London's "danger zone."

Dry Insulating Machine.

There has recently been introduced a machine for treating such electrical parts as armatures, field and magnet coils, with insulating varnish by the twofold effect of vacuum and pressure. By the employment of both these agencies, it is claimed, not only are the outside surfaces coated, but the varnish is forced into every part and every interstice of the coil or armature under treatment, thus insuring thorough insulation. Some idea of the apparatus may be gathered from the accompanying illustration, the operation being as follows: after the articles to be treated have been placed in the machine they are heated to the requisite temperature, and while hot are subjected to a high vacuum, whereby the air and any moisture or vapour are drawn off.

Insulating varnish is then drawn by the vacuum into the impregnating chamber through a suitable arrangement of pipe and valves, completely flooding the articles under treatment. Air pressure is then applied, forcing the varnish into the coverings as stated above. The varnish is then drained away, and the heat which is still applied dries the articles thoroughly before they are removed.

The cover is carried by side rods which hold it in position when closed, and when open swing on a pivot to carry the cover entirely out of the way, but holding it in a convenient position to close at once. The thermometer is carried in a special chamber in the body of the apparatus. The articles may be watched all the time they are under treatment, and if the varnish undergoes any change under heat, or vacuum, it may be seen and remedied.

The apparatus, known as the Simpson and Brown patent, is manufactured by A. G. Brown, King Street West, Manchester.

Automatic Grinding Machine for Involute Cutters.

A machine of the Sellick pattern for grinding involute cutters, and forming the subject of the illustration on page 371, has been recently introduced by Messrs. Selig, Sonnenthal & Co., 85, Queen Victoria Street, E.C., by whom it was shown at their stand at the Franco-British Exhibition. The machine is completely automatic; once the milling cutter is set, all the operations of grinding can be carried out without the aid of an operator. Two slides are employed: a working slide *M*, which carries the whole of the mechanism, and a setting

slide *C*, used for adjusting the machine for cutters of various size.

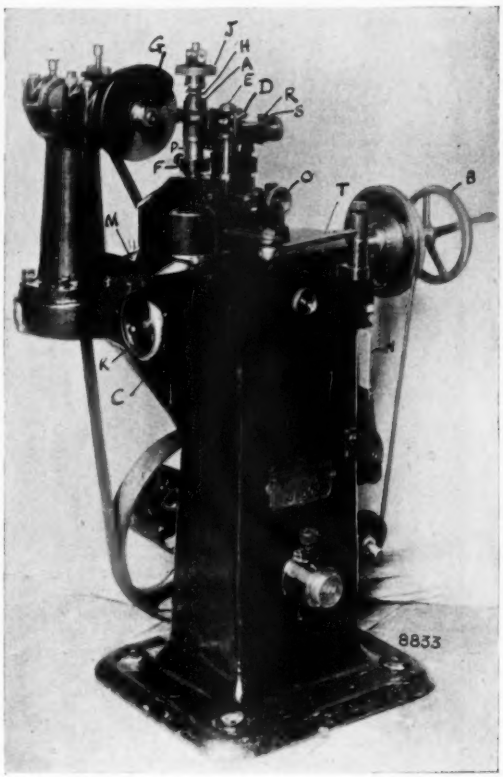
The cutters, which are mounted on standard bushings hardened and ground to fit the stem, are automatically advanced one tooth on each cycle of the slide *M*, and a definite stop *D* positions the cutter each time it is rotated. The feed is obtained automatically through the stop *D*, which is carried on a slide *R* actuated by a pawl and ratchet wheel upon each revolution of the cutter. The stop is so arranged that it is traversed up the back of the tooth and gives an equal feed to all teeth of the cutter. The amount of feed is adjustable, and a safety stop is provided to prevent unnecessary grinding and automatically throws the machine out of gear. The emery wheel is of the ordinary type, and is mounted on a spindle *G* carried in ball bearings. The wheel is adjustable on its spindle endways to allow for wear of emery wheel.

In setting the machine the cutter is placed on the bushing *A*, the collar *F* adjusted to bring the cutter central with the spindle *G*, the spring *H* placed on the cutter, and the nut *J* screwed down to prevent the cutter turning on the return motion of the pawl *E*. The slide *M* is then run to the end of the stroke nearest the emery wheel by means of the handwheel *B*, and the setting slide *C* adjusted by means of *K* to let the emery wheel run into the bottom of the cutter tooth space. The cutter is then set so that the face of the tooth just clears the emery wheel and the stop *D* set to the back of the cutter tooth. The handwheel *B* is then turned until the slide *M* reaches the opposite end of the stroke, and the pawl spring *E* set on to the cutting face of the cutter tooth. The machine is now run round by hand and the belt lever *N* then struck.

The cutter can now be quickly brought into contact with emery wheel by means of worm *O*.

Each time the cutter completes a revolution the bush *P* (which is carried round by the cutter) engages with a lever carried beneath the stop slide *R*, which actuates the mechanism, *S* feeding the stop into the angle on back of cutter teeth and giving the necessary feed to emery wheel. The pawl and ratchet motion *S* is supplied with a stop to safeguard against unnecessary grinding.

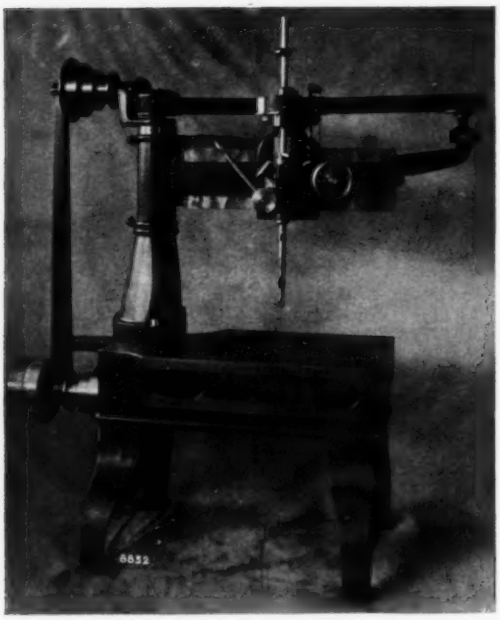
Upon the return stroke of the cutter from the emery wheel the stop slide is drawn down by means of a cam motion actuated by arm *U* and the cutter advanced one tooth by means of pawl *E*, which is actuated by arm *T*.



AUTOMATIC GRINDING MACHINE FOR INVOLUTE CUTTERS.

Two New Machines.

The sensitive radial drilling machine forming the subject of the first of the two following illustrations has been specially designed for dealing with large and awkward castings, and embodies several important features. For example, there is the table. This is of box section surfaced on the top and on the front side, which enables the work to be bolted and set



SENSITIVE RADIAL DRILLING MACHINE. MESSRS. A. HAWORTH & CO.

quickly in alignment with the spindle. Angle plates may thus be dispensed with and long work may be operated upon the ends. The arm, as will be seen, is of very substantial construction, being well ribbed. It swings on the round column and may be locked in any position. The spindle is driven by an endless belt, enabling the head to be traversed along the arm and fixed in any position. The head is moved along the arm by rack and pinion with a hand-wheel placed in front of the machine. The spindle revolves in a long sleeve provided with an adjustable cap, which, however, is not split on one side of its bearing. The thrust is taken on ball collars. The spindle driving pulley revolves in a long bearing, thus relieving the spindle of strain.

To ensure absence of vibration and good balance the pulleys are turned inside and out. They are run on fixed studs made to stand the strain of the belt. For repetition work an adjustable collar is fixed on the spindle and acts as a stop. An adjustable stud for taking up any slackness of the belt is also provided. The following are the leading particulars of the machine :—

Vertical movement of spindle, 5 in.; vertical movement of sliding head, 8 in.; drills up to 29 to 32 in. No. 2 M.T.; diameter of spindle, 1 in.; distance from under arm to table, 18 in.; working surface of table, 3 ft 6. in. × 2 ft.; maximum distance from centre of spindle to centre of column, 2 ft. 6 in.

The second machine, which has also recently been put on the market, is a small slotting machine which embodies some advantageous features. For example, the tools supplied are of a special nature and are held on to the ram by means of a special tool holder, thus eliminating forging, which would otherwise be necessary. Then there is a device by which the top slide is set central by means of a spring-backed plunger, together with an attachment fitted to this which allows of all work placed upon the machine to immediately lie in a central position. Thus a correct setting is made without use of rule or measuring appliances of any description.

Another feature is that the ram is provided with a 7½ in. adjustment in its stroke, which can be operated whilst in motion, thus dispensing with packing the work. For repetition work an adjustable dead stop is provided, so arranged, however, as to allow the work to pass for removal, but going back to the original position afterwards. A circular attachment is provided, enabling a wide range of work to be executed, such as cutting out square, hexagonal, &c. holes, cutting notches round a disc to any factor of 360. The worm can be put out of gear and the following divisions 2, 3, 4, 6, and 8, can be obtained from a spring plunger without using the index dial. The following are the leading dimensions:—stroke—0 to 5 in.; admits under head, 15 in.; travel to and from body, 14 in.; transverse travel, 14 in.; will slot pulleys 23 in. diam.; surface of top table, 12 × 10 in. Both machines are manufactured by Messrs. A. Haworth & Co., Luton, Beds.

New Type of Circuit Breaker.

Messrs. The Switchgear Co., Ltd., of Newhall Street, Birmingham, have recently placed upon the market a new form of circuit breaker. This is known as model "E," and, whilst embodying several

new features in circuit breaker construction, retains those which the firm has found most reliable with this class of switchgear.

The circuit breaker is closed by a pull-down motion, the power being transmitted through a carefully designed toggle movement, and the brush presses downwards on to the top surface of the upper contact, and upwards on to the underneath surface of the lower contact. The brush is of the laminated pattern, and has auxiliary copper and carbon breaks.

The tripping of these circuit breakers is effected by means of a push button in the end of the handle in the case of small breakers which are provided with straight handles. Larger sizes of this pattern of circuit breaker are provided with handles of the reel type carried by a stirrup, which enables the operater to obtain a much better grip of the operating handle, and in such breakers the tripping is effected by means of a push button situated in a position suitable for easy operation by means of the thumb while the handle is gripped.

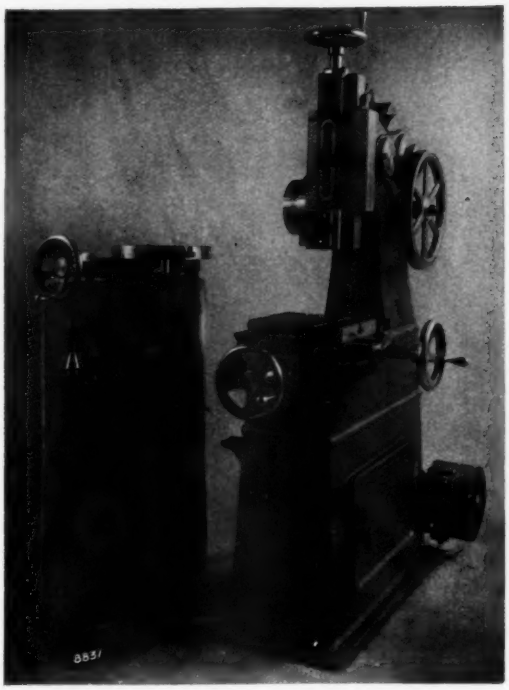
The makers of this apparatus regard the tripping of circuit breakers by means of an upward movement of the handle as undesirable, as anyone passing the switchboard may, by a touch of the handle, cause it to trip when not intended to do so. With the push button device they claim that this is practically impossible, while equal rapidity of operation is provided thereby.

A special feature is the ease with which the circuit breaker is closed, especially in the case of the heavy types; the 3,000 ampere size can be very easily closed by one hand, owing to the special toggle movement and long leverage.

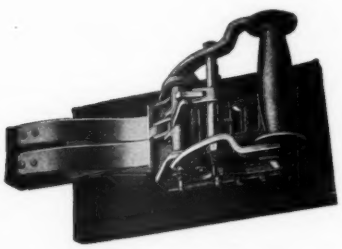
With this model a free handle is provided, and it is arranged for fitting with the Statter time lag. It may be mentioned that with this device the circuit to be controlled may be loaded continually to its full capacity and be amply protected against overloads, since the action is a true inverse time limit.

For reverse current or no-load operation, model "E" circuit currents are fitted with the Sugden and Rodway reverse movement, the most important features of which are that its action is independent of bus-bar pressure, and that it will operate even with a sudden heavy reversal of current such as would be produced by an attempt to switch in a standing generator.

These circuit breakers are made in sizes ranging from 50 to 3,000 amperes, and in all combinations as single, two, or three pole, with overload, reverse, or no-volt feature



SLOTTING MACHINE. MESSRS. HAWORTH & CO.



NEW TYPE OF CIRCUIT BREAKER.

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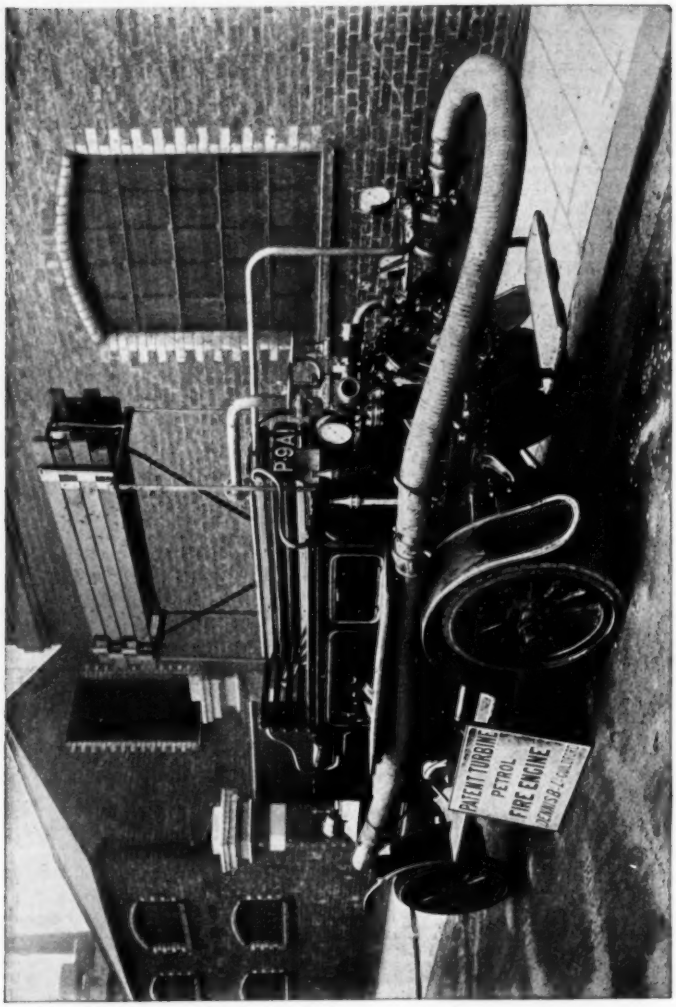

THE "DENNIS" TURBINE FIRE ENGINE.

for direct or alternating work up to 600 volts.

The illustration is of the 3,000 ampere size, with reverse current movement.

The Dennis Turbine Fire Engine.

One hundred years ago fire fighting appliances usually consisted of one or perhaps two hand-squirts, and a dozen buckets. Here and there a combined pedal and hand pumping machine was owned, and fortunate indeed was the brigade owning a manual pumping engine. Sixty-eighty years ago the first steam fire engine was built. It was self-propelled; the engine serving the dual purposes of propelling and pumping. It was not, however, a success; the weight was too great and the cost of construction and

upkeep prohibitive, and after modifications were made in both engine and pumping plant the self-propulsive idea was abandoned. The horsed steam fire engine was thus evolved in the early days of motor traction; to-day the horsed steam fire engine has reached the acme of perfection, but it lacks one thing, viz., speed. Only the abandoned system of self-propulsion can give it this. The motor steam fire engine is now almost as heavy as its parent. Moreover, it is costly to run and to keep up steam when in the station. These drawbacks are to a certain extent overcome by the speed with which it will turn out for and arrive at a fire. There remains, however, the difficulty of utilising the pressure of water hydrants, amongst other details, which some maintain cannot be remedied so long as the present types of steam pumps are maintained.

The solution of many difficulties of steam fire pumps, whether horse or steam power propelled, would appear to be reached by the aid of the petrol engine, a type well suited for pumping and propelling. The question of the kind of pump to be employed with this type of engine is of importance. Pumps of the ordinary steam fire engine type have been tried, but it was found impossible to obtain the maximum efficiency of a petrol motor in a pump with an intermittent or thrusting movement, however much the number of cylinders of pump or motor may be multiplied.

The difficulties encountered with the centrifugal pump appear to have been overcome in the Gwynne-Sargeant centrifugal or turbine pump used on a new type of motor-driven fire engine recently constructed by Messrs. Dennis Bros., Ltd., Guildford. The pump is self-charging; there is always a good vacuum maintained, and the pump will commence to deliver water a few seconds after placing the suction strainer in the water. Only one casing is necessary, as the vanes are in a triple row, two outer and one inner. The water is caught by the outer vanes and thrown to the inner vanes, which force it into the distributing chamber. Water enters on both sides of the pump casing and obviates the end thrust noticeable in other types of pumps. It is capable of discharging 350 to 400 gallons of water per minute at a sufficient pressure to play two $\frac{7}{8}$ in. or 1 in. jets 120 ft. high. Further, presuming at the site of the fire there is a water main carrying pressure, such a main can be connected directly to the suction of the pump, and the pump will add to such pressure another 200 ft. In fire engines of the ordinary type the pressure in the mains is wasted by letting the water out into a suction tank and then drawing it up again.

No dam is necessary with this pump, nor are valves required, consequently the pump is able to deal with muddy water or sand. One great advantage of this freedom from clogging and of damage to valves renders the appliance most suitable for withdrawing water from a basement during salvage operations after a fire or storm.

The transmission system from the engine to the pump is exceedingly simple. Over and geared to the clutch shaft driving the road wheel gears is a shaft which has no connection whatever with the road gears. Normally the pump shaft is not in mesh with the clutch shaft. As soon as the vehicle stops at a fire, a small lever is pulled over and the pump shaft is put into mesh with the clutch shaft, still being driven from the engine. The road gears are in the "neutral" position when the pump is at work. The latter is always kept fully charged, and is therefore ready to work the moment the pump and clutch shaft gears are placed in full mesh. Both these gears are enclosed in an oil-tight aluminium casing quite separate and some distance from the road gear box.

The charging apparatus of the fire pump can be used as a first-aid machine should the main pump supply not be required. By starting the pump a continuous supply of water from the forty-gallon charging tank is delivered through a 1 in. hose with $\frac{5}{16}$ in. nozzle; the supply is maintained by coupling a hydrant to the pressure. The main lines of $2\frac{1}{2}$ in. or $2\frac{3}{4}$ in. hose can be brought into play at any time whilst the 1 in. aid hose is at work should the fire assume serious proportions.

The road gear transmission is to a patented gear box with four speeds and reverse with direct drive on third speed and geared fourth speed. From the gear box the drive is taken to the back axle by a worm on the propeller shaft operating in a worm wheel fixed on the back axle and carrying star differential gear.

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Iron, Steel and the Foundry.

Conducted by PERCY LONGMUIR, B.Met.

THE AUTUMN MEETING OF THE IRON AND STEEL INSTITUTE.

The Mechanical Cleaning of Iron Ores.—Mr. T. C. Hutchinson bases his paper on the statement that it is much cheaper to pick out certain impurities than to melt them out in the blast furnace. From the data given in reference to variation in smelting results, it is shown that varying impurities in the iron ore have a large influence. From 1895 to September, 1901, ironstone smelted as delivered from the mine gave results as stated in the first table.

An examination of the increased consumption of materials per ton of pig iron made led to a recognition of the effect of impurities mechanically present in the ore. The installation of a cleaning belt reduced the consumption of materials per ton of pig iron made to 102·92 cwts. The following table gives the actual cost of smelting the same main bed of ironstone, but with

Year.	Ironstone used per ton of iron made.	Limestone used per ton of iron made.	Coke used per ton of iron made.	Total mineral used per ton of iron made.
	Cwts.	Cwts.	Cwts	Cwts.
1895	67·372	12·698	22·440	102·510
1896	67·852	13·928	21·340	103·120
1897	68·106	13·964	21·736	103·806
1898	67·818	14·240	21·494	103·552
1899	68·084	14·236	22·552	104·872
1900	69·254	14·664	23·184	107·102
1901 (Jan. to Sept.)	68·61	15·39	22·56	106·56

Ironstone containing metallic iron, per cent.	Material consumed per ton of pig iron produced.		Cost of material used in smelting ton of pig iron.
		Cwts.	£ s. d.
27·34	Ironstone	67·22	0 18 5·826
	Coke	21·90	0 18 0·81
	Limestone	13·80	0 3 5·4
	Total	102·92	2 0 0·036
26·28	Ironstone	70·02	0 19 3·066
	Coke	23·09	0 19 0·591
	Limestone	13·61	0 3 4·83
	Total	106·72	2 1 8·487
25·52	Ironstone	72·104	0 19 9·9432
	Coke	23·581	0 19 5·4519
	Limestone	15·845	0 3 11·535
	Total	111·530	2 3 2·9301
4·97	Ironstone	72·784	1 0 0·1872
	Coke	24·647	1 0 4·0053
	Limestone	15·471	0 3 10·413
	Total	112·902	2 4 2·6055

varying admixtures of impurities as delivered from the mine and containing in the thereinmentioned samples the specified amounts of iron.

At the present date (August, 1908), about 13 per cent. of impurities are mechanically removed from the ore by the cleaning belt. Adjustable slots on the shoot permit the bulk of the small to pass direct on a transverse belt which carries it on to the shale trough on the main belt. The larger pieces of shale are picked out by boys who travel with the belt, until the ironstone is cleaned and passed over the end of the belt into trucks ready for delivery to the calcining kilns. The conclusions reached by the author are:—

(1) The whether these impurities are charged into the furnace in larger or smaller percentages as compared with the main bed of ironstone, the coke and limestone requirements, and the cost of smelting increase in exact ratio.

(2) That it is cheaper to pick out impurities mechanically than to smelt them out in the blast furnace.

(3) That mechanical cleaning is desirable and can be applied to all descriptions of ores used in the manufacture of pig iron.

The Iron and Steel Industries of Cleveland during the Last Quarter of a Century.—Mr. W. Hawdon reviews progress made since the last visit of the Institute to Middlesbrough. The make of pig iron has been as follows:—

	1883	1893.	1903.	1907.
	Tons.	Tons.	Tons.	Tons.
Cleveland and basic	1,855,508	1,388,043	1,978,795	2,417,062
Other kinds ...	905,232	1,336,141	1,129,255	1,117,006
Total ...	2,760,740	2,724,184	3,108,050	3,534,068
Furnaces blowing—				
On Cleveland	84	43	41	42
Other kinds ...	33	41	34	36
Average weekly make per furnace—				
On Cleveland	424	717	928	1,196
Other kinds ...	527	526	638	597

A notable change in blast furnace practice lies in the increased make per furnace, the average being 1,106 tons per week, and the best practice noted for an individual furnace on Cleveland iron is 1,344 tons per week for over three months. The tonnage of iron and steel manufactured in the Cleveland and North East Coast district is as follows:—

	1883.	1893.	1903.	1907.
	Tons.	Tons.	Tons.	Tons.
Open hearth basic	*Nil.*	*Nil.*	139,784	416,207
Open hearth acid	10,000	482,120	755,044	955,331
Bessemer basic	304,606	168,538	336,859	281,641
„ acid	Not divided in returns	205,164	24,668	96,168
Iron manufactured:—				
Total Cleveland puddled bar ...	794,170	227,402	119,087	84,964
Total ...	1,108,776	1,083,224	1,335,422	1,834,311

These figures are of moment, but special interest is attached to the Bessemer steel returns. It will be noted that whilst the total make of Bessemer steel has practically not increased since 1893, it is now mainly made from Cleveland iron, whereas it was largely made from hæmatite. In commenting on blast furnace developments the author draws attention to the utilisation of power. The old-fashioned blowing engines, driven by steam at 65 lbs. pressure, consume about 40 lbs. of steam per h.p. Modern high pressure condensing engines or turbines consume about 40 lbs. of steam per h.p. Turbines worked on exhaust steam consume 32 lbs. of this steam per kw., or 25 lbs. per brake h.p. With a furnace making, say, 150 tons per day or 1,050 tons per week, about 600 h.p. is required to drive the furnace blowing engines with about 6 lbs. pressure of blast. There is, therefore, a large amount of power available for other purposes than the blast furnace. This can be obtained either from the exhaust steam of the old engines, by putting in compound condensing engines, or by putting in tubular boilers which require only about two-thirds the amount of gas, as the old Cornish or Lancashire boilers, for the same evaporation. By this means there should be a surplus of gas, which can be utilised in gas or steam driven engines equal to about 620 h.p. per furnace through the medium of steam. With gas engines this h.p would be, of course, much higher.

The Scientific Control of Fuel Consumption.—According to Professor H. E. Armstrong, this subject is of imperial and urgent importance, and an organised attack on the problems awaiting solution is imperative. In a large measure salvation is to be found by the employment of specially

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trained chemists, but until then the author's opinion is that the fullest possibilities will not be reached in the industrial use of fuel. The suitable chemist is represented by the man whose imaginative powers have been so cultivated as to give him an insight into the very heart of the processes he directs. The mind of the engineer leans more to the constructive side. In attributes and functions the two are no more alike than are the painter and the musical composer. In all industries dealing with chemical processes their labours should be conducted on parallel lines in a spirit of mutual co-operation. The gas industry is a striking illustration of the danger of overlooking this need; on the engineering side it has been developed to a remarkable pitch of perfection; on the chemical it still remains the barbaric process it was at its inception—the engineer having always assumed control practically to the entire exclusion of the chemist.

Blast Furnaces from 1844 to 1908.—Mr. Greville Jones gives an admirable description of Messrs. Bell Bros.' blast furnaces, showing the development from 1844 down to to-day. The growth of the firm is given in narrative form, and the gradual evolution of the blast furnaces is shown in a series of valuable figures. By way of illustrating blast furnace development, we append a few figures taken from some of the many records given by the author:—

Lining.	From.	To.	Total make.		Average per week.	Coke.	Mine.	Lime and limestone.
			Tons.	Cwts.		Cwts.	Cwts.	Cwts.
No. 1 Furnace.								
1st	Jan. 27th, 1854	Nov. 18th, 1859	47,973	18	159	32·39	48·24	16·84
2nd	Jan. 5th, 1861	Jan. 17th, 1866	58,437	9	223	28·98	48·43	10·91
3rd	Apr. 29th, 1867	Mar. 21st, 1878	147,966	16	261	23·19	49·42	10·80
4th	Oct. 20th, 1879	Sept. 7th, 1886	118,482	1	329	21·30	46·90	10·63
5th	Jan. 18th, 1894	Apr. 27th, 1908	421,034	5	566	22·37	47·44	12·64
No. 7 Furnace.								
1st	May 4th, 1865	Feb. 9th, 1877	188,963	1	311	23·11	48·83	10·94
2nd	Sept. 2nd, 1879	Sept. 23rd, 1898	474,533	12	500	22·02	47·50	11·48
3rd	July 16th, 1900	Dec. 10th, 1905	238,310	0	8 6	22·86	46·76	12·58
4th	Apr. 15th, 1907	July 18th, 1908	61,122	14	926	20·96	42·19	12·93
No. 11 Furnace.								
1st	Oct. 26th, 1875	Nov. 9th, 1895	476,562	8	457	22·30	46·80	11·03
2nd	Sept. 23rd, 1896	Dec. 21st, 1905	449,525	14	931	23·00	41·94	12·13
3rd	Oct. 9th, 1907	July 18th, 1908	41,752	12	1018	21·70	47·93	12·71

Further Experiments upon Gas Producer Practice.—Professor Bone and Dr. Wheeler give a continuation of the experiments reported at the Spring Meeting, 1907. The earlier paper advanced the plea that admixture of more steam with the air blast than corresponds with a saturation temperature of from 60° to 65° C. is not conducive either to higher thermal efficiencies or to the generation of a gas specially suited for furnace work. The present paper records the results of a further series of experiments, and tends to show that still lower steam saturation temperatures result in an effective combination of rapid rate of gasification and high thermal efficiency. This can be continuously maintained under ordinary work conditions, furnishing a rich gas of high carbonic oxide, content and eminently adapted for either power or heating purposes.

The Chemical Control of the Basic Open Hearth Process.—Messrs. Harrison & Wheeler commence with the proposition that the basic open hearth process is essentially a chemical problem, and then promise to indicate how far the chemist can control the process. However, before doing this, the authors discuss the correct treatment of the chemist. The argument advanced is that the chemist should be put on an equality with the engineer. "It is the chemist's chief function to *interpret* results; it is he alone who can be trusted with the correct interpretation of results and the practical carrying out of his deductions. He should, therefore, be valued chiefly in his advisory capacity, and should be accorded a position and powers commensurate with the importance of his functions." This section represents the most definite part of the paper, and is followed by a description of methods for the rapid estimation of carbon, phosphorus, and sulphur on the furnace stage.

Further Developments of the Metal Mixer and the Open Hearth Process.—Mr. A. E. Pratt commences

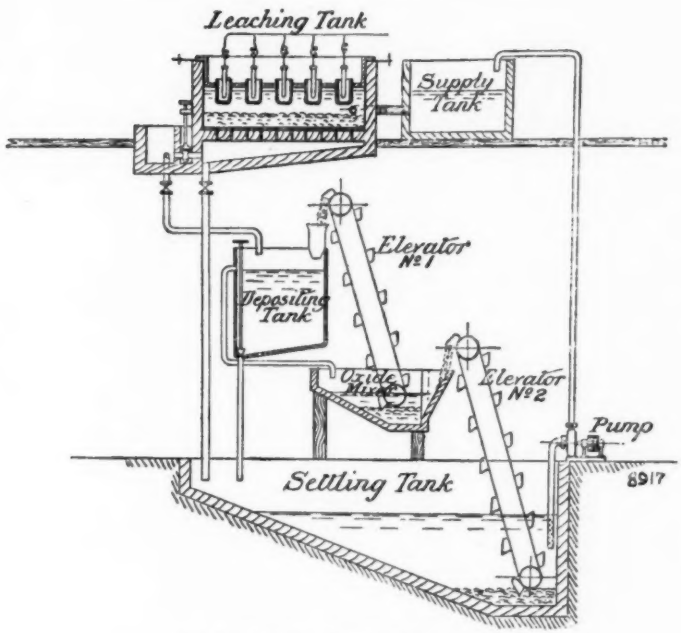

FIG. 1.—GENERAL ARRANGEMENT OF PLANT.

with a review of the development of the metal mixer, tracing its evolution from the 80 tons mixer of the Edgar Thomson works down to the Ebbw Vale mixer of 750 tons capacity. The metal mixer is at present employed mainly for the following purposes :—

(1) To save remelting.

(2) To secure a constant stock of metal of uniform composition.

(3) In special cases to effect desulphurisation by the use of high manganese metal.

(4) In all cases there is a certain amount of purification, in addition to uniformity, but this is usually an incidental advantage rather than one of the definite objects of the mixer.

Briefly expressed, the author's proposals lie in extending the work of the mixer by increasing the amount of purification done in it and leaving less work to be done in the open hearth furnace. The mixer slag is maintained in a basic condition, and additions of calcium chloride, fluorspar, &c., are made to increase the fluidity. From time to time oxides and lime are added to the slag in order to maintain its oxidising and basic nature, and to replace portions of foul slag which are poured off. Such a slag will act as a refining agent while the mixer metal is waiting to be taken away for further treatment, serving partly as a washer for the charges of blast furnace metal and partly in the same way as the slag in an ordinary basic open hearth furnace. The mixer should be gas fired and lined with a basic material. In place of the mixer a large tilting open hearth furnace, known as a "finer," may be employed. Further proposals include a furnace known as the "scrapper," in which scrap is melted down; a series of furnaces, either fixed or tilting, and known as "finishers." A charge of molten scrap is made to one of the finishing furnaces; pre-heated oxides and lime are then added, and a charge of "finer" metal introduced. Owing to the heat contained in the molten scrap a violent reaction occurs between the carbon in the "finer" metal and the molten oxides, the carbon together with any small amount of other metalloids being rapidly eliminated. The bath of metal is finished in the usual way by such further additions as may be

required, and is tapped completely from the furnace. These proposals are intended to effect the following :—Melting down period in the scrapper ; exothermic reaction period in the finer, and the endothermic reaction period in the finishers. The three chief periods are carried out simultaneously and independently. Further, the high temperature required for efficient carbon elimination is instantaneously attained owing to the method of mixing the charge from the finer with the highly heated molten scrap from the scrapper.

The Production of Finished Iron Sheets and Tubes in One Operation.—Mr. Sherard Cowper-Coles describes methods for the electrolytic deposition of tubes and sheets, and also gives much valuable information on the production of electrolytic iron. The process consists in placing crude iron or finely divided iron ore in suitable containing vessels in which an acid solution is circulated, using an insoluble anode material ; or, further, the process may combine the use of soluble and insoluble anodes. The crude iron or iron ore being in each case connected to the positive pole of a dynamo, the iron goes into solution and is deposited on cylinders or plates, which may be either rotated or stationary, depending upon the class of finished product required. A general arrangement of the apparatus is shown in Fig. 1. When it is desired to produce a highly finished sheet a metal sheet of the desired surface is wrapped round the cathode and held in position by means of grooves and wedges. By employing a mandrel, say, 8 ft. in diameter, a sheet 24 ft. by 5 or 7 ft. can be produced. When it is desired to produce tubes, iron mandrels, somewhat smaller than the internal diameter of the finished tube, are coated with lead by electro-deposition, or by having lead drawn over them. Thus prepared, the mandrels are rotated in an apparatus of the type shown in Fig. 2. When the desired thickness of iron has been deposited, the mandrel is heated to a temperature sufficient to melt out the lead and thus admit of its easy withdrawal.

In discussing the properties of electrolytic iron the author shows that hydrogen is always present in varying quantities according to the conditions under which it has been deposited. The greater the amount of hydrogen the greater the hardness, and the hardest varieties of electrolytic iron will scratch glass. There are two distinct varieties of electrolytic iron, with varying contents of hydrogen ; the softer kind is silver grey in colour, whilst the other variety is hard and brittle, breaking as readily as glass, and containing a higher percentage of hydrogen. Either quality can be produced at will by increasing or decreasing the electro-motive force at the terminals of the cell. When annealed the iron gives off large quantities of hydrogen,

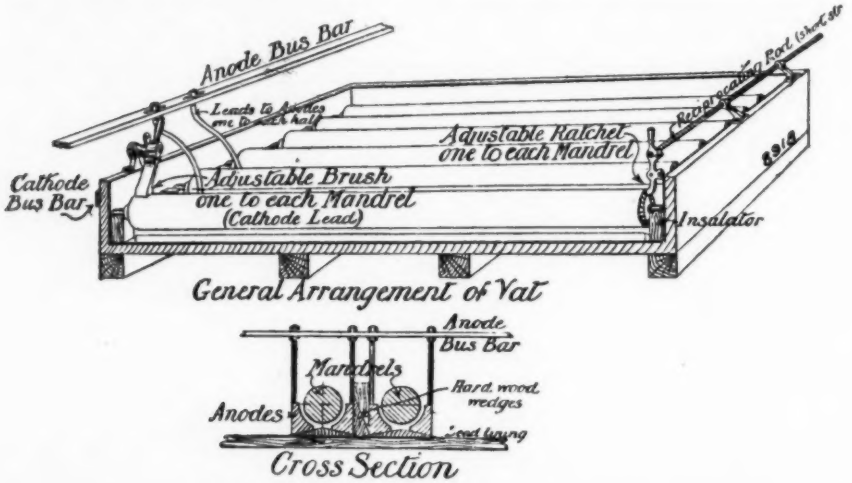

FIG. 2.—APPARATUS FOR THE DIRECT PRODUCTION OF TUBES.

No.	Authors.	Date.	Gas in contact with iron.	Freezing point of iron.
1	Carpenter and Keeling.	1904	Products of combustion of coal gas in air.	1505° C.
2	Guertler and Tammann.	1905	Nitrogen.	1492° C.
3	Harkort.	1907	Carbon monoxide.	1504° C.
3	"		Oxygen.	1501° C.
4	Saklatwalla.	1908	Nitrogen and Hydrogen.	1510° C.

and even at 100° C. distinct amounts of hydrogen are evolved.

A Test for Ascertaining the Relative Wearing Properties of Rail Steel.—Mr. E. H. Sainter has devised a testing machine the purpose of which is to imitate the conditions of actual practice whilst at the same time completing a test within a reasonable time. The principle of the test is that of a round test piece revolving a fixed number of revolutions and rotating by friction the inner ring of a ball-bearing loaded with a fixed weight, the action being very similar to the action of a wheel rolling on a rail. The test pieces are carefully measured before and after testing, and the wear test number is the number of ten thousand parts of an inch by which the diameter has been reduced. The smallest wear number corresponds to the least wear, and therefore represents the best wearing steel.

The Freezing Point of Iron.—Professor Carpenter reviews the work done in this field, and gives a summary of the determinations recorded since 1904. These results are given in the above table.

The conclusion drawn from this table is that the freezing point of iron is independent of the atmosphere in which it is determined, whether this be oxygen, nitrogen, air, carbon monoxide, carbon dioxide, hydrogen, or mixtures of these. This is of special interest in regard to oxide of iron, which, notwithstanding its solubility in iron, is without effect on the freezing point. The author promises an explanation of this rare if not unique fact at no distant date.

By ANDREW STEWART, A.M.I.E.E.

The Electrification of the Melbourne District Railways.

The report which Mr. C. H. Merz has submitted to the Victorian Railway Commissioners on the proposed adoption of electric traction in the neighbourhood of Melbourne is a most interesting document. To many his advocacy of direct current at 800 volts pressure will come as a surprise, but the circumstances seem to justify his conclusions, and his choice is backed up by figures and arguments which his critics will find difficult to refute.

After pointing out that so many suburban lines are now operated electrically that electric traction is no longer experimental, Mr. Merz proceeds to outline the many advantages not only to the railway authorities but to the public which follow from electrification. Most of these are, of course, apparent to our readers, though Mr. Merz presents a formidable array of points under these headings.

Acceleration plays a most important part in electric railway economy, because

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FIG. 1.—METHOD PROPOSED OF FIXING CONDUCTORS IN THE SIX-FOOT WAY.

it enables high average speeds to be maintained, and renders coasting possible for a considerable length of run, so that the considerable energy consumption inevitable when high acceleration is achieved is neutralised to a certain extent by the driver shutting off current over a large part of the distance travelled. Moreover, lost time can be made up by keeping current on during the period usually devoted to coasting.

The schedule speed on the Melbourne suburban lines under steam is 16 m.p.h.; it is proposed to raise this to 20. Other lines, such as the Pennsylvania Railway, West Jersey, with an average distance of 8,800 yds. between stops, has a schedule speed of 28·8 m.p.h.; Liverpool Overhead Railway, 670 yds. between stops, 19 m.p.h.; and Central London Railway, 840 yds. between stops, 14 m.p.h. The Melbourne lines have an average of about 1,100 yds. between stops.

The acceleration required to maintain the schedule speed just suggested for the Melbourne lines is 1·35 ft. per sec. per second. This is about the upper limit of modern practice, and Mr. Merz justifies it by means of curves showing the energy consumption with different accelerations. From these it is evident that the critical acceleration lies somewhere between 1·2 and 1·35 ft. per sec. per second. Above this there is little economy to be gained, below the lower figure operation becomes less economical.

Mr. Merz suggests as a normal train one motor car and one trailer, with a seating capacity of 160, the former to be equipped with two motors on one bogie of the motor coach. All trains to be multiples of this, and while some routes would require only a two-car train, others, especially busy suburban lines, would require during the morning and evening six or eight car trains.

A most exhaustive examination of the relative merits of the various systems of electric traction ends in the elimination of all except the unprotected third-rail direct-current system 500—600 volts, the protected third-rail direct-current system 800 volts, and the single-phase overhead wire system.

The success of the unprotected third rail in this country is undoubted, but, as Mr. Merz shows, the 800-volt direct-current system can be installed at somewhat lower cost than the 500—600 volt system, and, owing to the lower conductor losses, can be operated at less expense.

Single-phase, notwithstanding its strong claims, was rejected because the overhead equipment would be more expensive than is

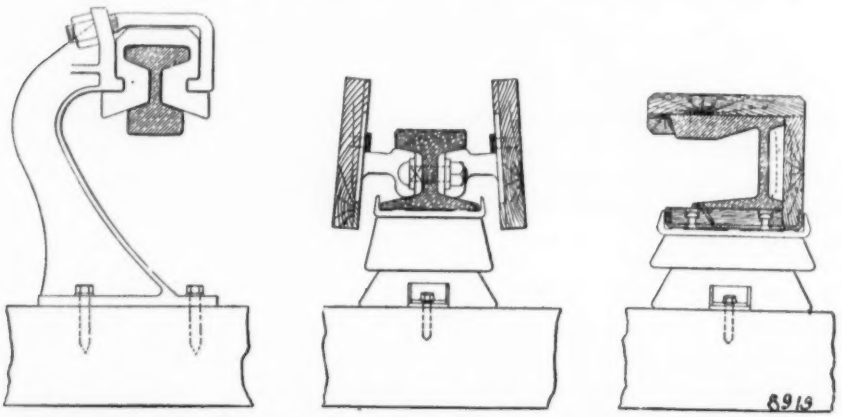

FIG. 2.—TYPES OF CONDUCTOR RAILS AND PROTECTING BOARDS.

generally supposed to be the case, and the extra cost of the large number of train equipments practically balances the extra cost of the sub-stations necessary with direct current. Among the advantages of the third rail compared with the overhead wire system is the important point that the conductor rail can be inspected and repaired by the usual permanent way staff, while inspection and repair of the overhead line of a single-phase system involves a different class of labour, and, moreover, their small overload capacity and the necessity of installing a larger plant than necessary with steam plant in order to deal with the fluctuations which would have to be taken, especially as the initial plant is small, and the ratio of maximum to mean load greater than would be the case later on.

It is proposed to fix the conductors in the six-foot way, as shown Fig. 1, which shows one type of protected conductor rail. Fig. 2 shows details of others, with the method of fixing the protecting boards.

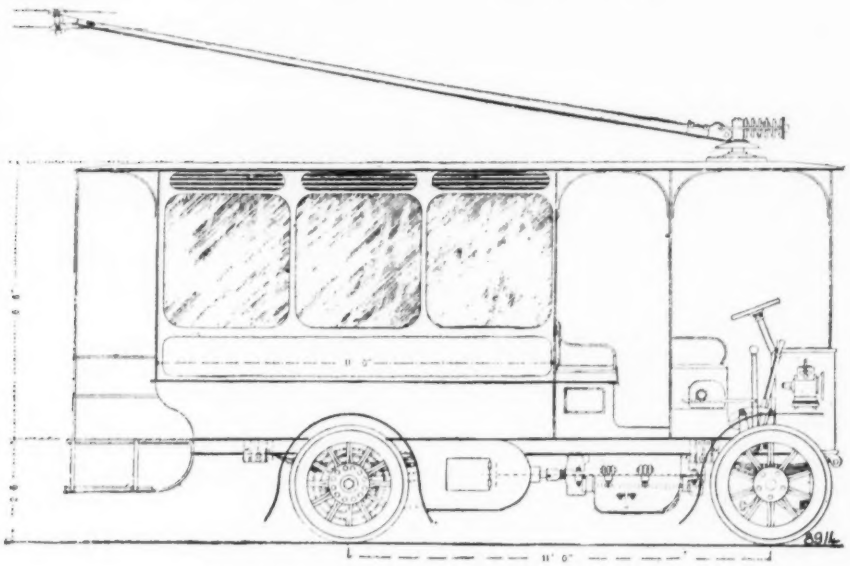

FIG. 3.—ELECTRIC OMNIBUS OPERATED FROM OVERHEAD WIRE.

even inspection can only be carried out when the normal traffic has ceased.

Wear of the third rail is small, practically negligible, but the overhead conductor requires frequent renewal on busy sections.

Mr. Merz figures that the energy per ton mile will be 83·7 watts (about ·112 h.p. hours per ton mile), and on that basis finds that the initial power station must supply a maximum of 1,920 e.h.p. Subsequently, however, over 32,000 electrical h.p. will be required.

Turbo-generators of 6,000 h.p. are proposed as being the most useful unit. They will run at 1,500 r.p.m., the periodicity of the supply being 25 cycles.

Gas engines as prime movers are discussed, but dismissed chiefly on account of

The operating costs of steam traction and the estimated costs of operation by electricity are given in the table below.

TABLE I. STEAM AND ELECTRIC TRACTION COSTS *per Train Mile.*

Section.	Port Melbourne and St. Kilda Branches.	Stage I.	Stage II.	Stage III.
Steam traction ...	19·38*d.*	19·06*d.*	18·96*d.*	18·93*d.*
Electric traction ...	13·34*d.*	12·1*d.*	11·52*d.*	11·03*d.*

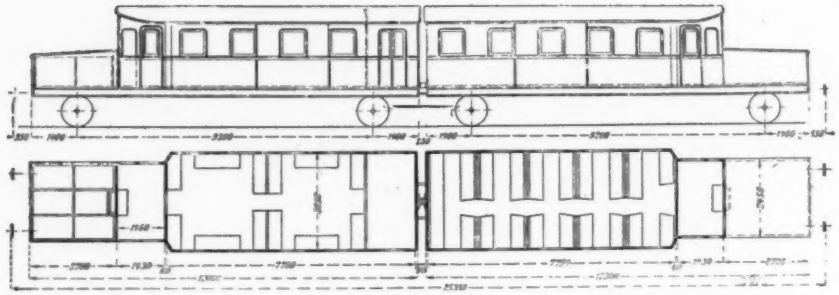

FIG 4.—ACCUMULATOR-PROPELLED RAILWAY MOTOR CAR: RUSSIAN STATE RAILWAYS.

Electric Road Vehicles with Overhead Wires.

Manchester Corporation, with an enterprise not at all characteristic of corporate bodies, have been considering the possibilities of what some of our contemporaries inaccurately describe as trackless trolley tramways, though when a tramway is not a tramway we leave others to decide.

These road vehicles take their energy from two overhead wires, a lead and a return, as there is no track for the return current, and are, strictly speaking, merely omnibuses electrically propelled, but picking up their power from an overhead wire, like a trolley car.

The Germans seem, so far, to be the principal exponents of this system, and a deputation from Manchester visited several of these lines, chiefly located in the smaller towns, and generally $2\frac{1}{2}$ to $3\frac{1}{2}$ miles long. The trolley poles, or booms, seen on the top of Fig. 3 are, in most cases, 18 ft. long, and in some cases there are two booms, one to each wire; in others one boom serves the dual purpose, having two insulated collectors.

As the vehicle does not follow a track but must move about the roadway to get round other traffic, these booms permit of considerable lateral movement of the car, as much as 10 ft. from the centre of the trolley line.

Steel tyres are usual; rubber tyres on the front wheels have been found expensive to maintain, while on the back tyres the maintenance was prohibitive, though it should be added that the roads generally were bad. One 25 h.p. motor driving on to the front axle has been the usual equipment.

The Railless Electric Traction Company have got out designs of an omnibus (Fig. 3) capable of carrying twenty passengers. It is fitted with an ordinary traction motor, which can be clearly seen in the figure, and drives, through a cardan shaft, a countershaft which has a differential gear, and which is connected to the driving wheels by a Renolds chain.

In their report the members of the deputation point out that this system is much cheaper to operate than petrol omnibuses, chiefly on account of lower maintenance and depreciation charges, and that these vehicles should prove useful pioneers for an electric tramway system.

Accumulator-propelled Railway Motor Cars.

Such cars are in operation on the Prussian State Railways in the vicinity of Mainz, also between Tempelhof and Zossen, and also on two lines in the Rhur district, while it is proposed to put some into service near Cologne at an early date.

The latest type of car is illustrated (Fig. 4), of which some 57 are now being built. The object of such cars is to supplement the suburban steam service, and to deal with traffic in sparsely populated districts, where a steam service would not prove remunerative. Fig. 4 shows one of these vehicles, which consists of two four-wheeled cars, the battery being located under the sloping roof at either end of the train of two vehicles. The object in placing the batteries in this position is that the only alternative is to put them under the seats, where the fumes prove offensive to passengers and act injuriously on the metal fittings in the car.

The two centre axles of the train are driven each by a 50 h.p. interpole motor, which, however, will give 80 h.p. for one hour. There are 84 cells in each compartment, 168 per train, and the normal working voltage is about 310 volts. The capacity

is 368 ampere hours, which will enable a train to cover 62 miles at a maximum speed of about 30 m.p.h. Series parallel control is employed, and the controllers are fitted with the "dead man's" handle, which, as our readers know, is used on the London underground railways. This handle, if released owing to the physical collapse of the driver, shuts off the current and applies the brakes. The accumulators are maintained by contact at 1·55*d.* per mile by the Akkumulatoren fabrik A.G. of Berlin. This maintenance contract extends for five years, after which it is presumed that the batteries are worn out.

NOTE.—The writer of these notes wishes to draw attention to the fact that in the September issue, when dealing with Mr. Durtnall's paper on Turbo-Electric Marine Propulsion, Mr. Durtnall is stated to have claimed 20—25 per cent. saving in steam consumption, and subsequently enlarged this to 40 per cent.

As a matter of fact, Mr. Durtnall lays no claim to the smaller of these economies, but claims to effect a saving of 40 per cent. in steam consumption when using his system.

The mistake occurred through the writer being in possession of an uncorrected proof of the paper.—A. S.

In this section is presented every month a list of the more important articles appearing in the Engineering Press and of the leading papers read before the various engineering institutions. Full names, addresses, and published prices of the publications indexed are printed each half-year in the volume index.

Civil Engineering.

The Construction Plant and Methods Employed on the Approaches of the Detroit River Tunnel. *Engineering Record*, 19*th September*, 1908.

Some Historic British Bridges. *Engineering News*, 17*th September*, 1908.

The King's Dock, Swansea. *Engineer*, 2*nd October*, 1908.

A Remarkable Bascule Bridge at Syracuse, New York. *Engineering News*, 24*th September*, 1908.

Details of the Construction of the Detroit River Tunnel. *Engineering News*, 24*th September*, 1908.

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Roofs, IX., X. *Railway Engineer*, *September*, *October*, 1908.

Nickel Steel for Bridges. By J. A. L. Waddell. *Proceedings American Society Civil Engineers*, *September*, 1908.

Wind Bracing with Knee Braces or Gusset Plates. *Engineering Record*, 5*th September*, 1908.

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Some Features of the Dry Excavation at Panama. *Engineering Record*, 5*th September*, 1908.

Depth of Water in Irrigation Canals. *Engineering News*, 10*th September*, 1908.

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Heating and Ventilation.

Materials and Measurements.

The Inhibitive Power of Certain Pigments on the Corrosion of Iron and Steel. Paper by A. S. Cashman before the American Society Testing Materials. *Engineering Record*, 19*th September*, 1908.

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The Testing of Foundry Irons. By F. J. Cook. *Iron and Coal Trades Review*, 11*th September*, 1908.

The Use of an Extensometer in Commercial Work. By T. D. Lynch before American Society Testing Materials. *Engineering Record*, 12*th September*, 1908.

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Standard Boiler House Design of the Oliver Iron Mining Co. *Engineering News*, 17*th September*, 1908.

Steam Traps. By Gordon Stewart. *Electrical Review*, 18*th* and 25*th September*; 2*nd October*, 1908.

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A Study of Low-Pressure Turbine Possibilities. *Engineering Record, 3rd October*, 1908.

Steam Turbine Development. By J. C. Thorpe. *Journal Western Society Engineers, August*, 1908.

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Air-Compressor Tests. *Mechanical World, 2nd October*, 1908.

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Some Notes on Hydraulic Plate Cutting and Riveting Machines. By N. S. Trustrum. *Journal Institution Engineers, 19th October*, 1908.

Shop Equipment and Practice.

Drop and Stamped Forgings. By Jos. Horner (*continued*). *Mechanical World, 18th* and *25th September*, 1908.

Machine Shop Work (*continued*). By Jos. Horner. *Mechanical World, 18th September* and *9th October*, 1908.

Shop Order Tracing System. *Mechanical World, 9th October*, 1908.

The Design of Twist Drills. *Engineer, 18th September*, 1908.

Threading Dies. *Machinery, September*, 1908.

Gauge for Testing the Planing of a Turret Machine Bed. *Machinery, September*, 1908.

Miscellaneous Mechanical Engineering.

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MANUFACTURERS' NOTES.

PETER HOOKER, LTD., notify that they have purchased and taken over from the liquidator of The Newall Engineering Co., Ltd., Warrington, the entire plant, stock, patents, and goodwill of that company's business in limit gauges, measuring machines, micrometers, surface plates, and other products, established now for about seven years, and will continue the same as a department of their own business under the name of The Newall Engineering Co., at their works, Blackhorse Lane, Walthamstow, London, E., as soon as removal from Warrington can be effected.—Mr. R. M. NEILSON, A.M.I Mech.E., has severed his connection with Messrs. Richardsons, Westgarth & Co., Hartlepool, and has opened an office as Consulting Engineer and Chartered Patent Agent at 45, Hope Street, Glasgow.—We are informed that Mr. BEN. H. MORGAN, of Queen Anne's Chambers, Westminster, has been appointed consulting engineer to the Clyde Engineering Co., Ltd., of Sydney, New South Wales, builders of locomotives, railway carriages, steam engines, pumps and agricultural machinery; and also to the Geelong Harbour Trust Commissioners, Geelong, Victoria.—GEORGE FISHER, Elektrostahlwerk, Schafthausen, intimates that he has opened at Schafthausen an electric steel works, turning out castings on the Héroult system, suitable for motor car parts weighing up to 1 ton.—AWARDS AT THE FRANCO-BRITISH EXHIBITION. Notifications have been received of the following:—Alfred Herbert, Ltd., Coventry, Grand Prix; Fastnut Ltd., Silver Medal in the Railway and Tramway Section.—THE COMBINATION METALLIC PACKING CO., LTD., Gateshead-on-Tyne, notify us that they have been awarded a Gold Medal and Diploma at a special exhibition in Russia. It is of interest to note the enterprise of this old-established firm in keeping ahead of the times and succeeding in securing the Highest Awards at Milan 1906, and now again at Moscow 1908, in spite of American and Continental competition.—Messrs. LANCASTER & TONGE, LTD., Pendleton, Manchester, makers of "The Lancaster" pistons, steam traps, and metallic packings, are making large additions to their works in order to meet the increasing demands for their specialities.

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